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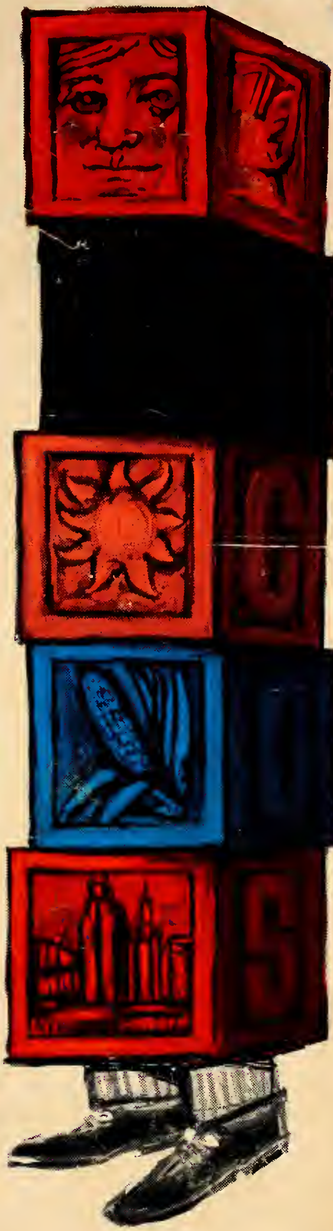

improvement through change

heredity

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diet

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IN SEARCH OF MAN

André Missenard

In a fascinating and reasoned discussion of the factors of human nature, Dr. Missenard shows how we can make radical changes in heredity, diet, climate and society—changes that will mold the man of the future. Demonstrating how intervention in nature can be extremely harmful, the distinguished scientist makes an impassioned call for an intelligent control over the present drift of human change.

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IN SEARCH OF MAN

by André Missenard

Translated from the French by Lawrence G. Blochman

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With respectful and affectionate homage to the memory of Alexis Carrel, my teacher and my friend, in an attempt to explain the scientific and humanitarian concern which brought him back to the humiliated and bleeding France of 1941.

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Foreword

Although he has devoted part of his life to higher education and scientific research, the author of this book is not what is conventionally called an intellectual. Fate decreed that in his youth he should assume various industrial responsibilities; that is to say, to wage—or submit to—struggles which, for all the courtesy with which they were conducted, were nevertheless violent, even implacable.

He was ill prepared for this career by his education at the *École Polytechnique* and was forced without warning into making decisions on questions raised by his social functions. He believed at first that the basic problem of industry was technical, and he threw himself passionately into research. But the balance sheet, sordid judge impervious to dreams, soon enlightened the puerility of his ideas. The primordial problem was not at all technical, even less scientific. He then understood that in all collective effort, the human questions take precedence, and that his job as animator was essentially one of finding suitable associates or collaborators and of making the most of his human resources. He was thus led to observe his fellows and to try to judge them.

The diversity of his many occupations—technical, commer-

cial, agricultural, scientific, and professorial—brought him into contact with a great variety of men, from great capitalist to humble laborer, from illustrious scholar to obscure illiterate. Divers scientific missions outside of France, particularly to the League of Nations, have made him fairly well acquainted with foreigners.

Finally, like most men of his generation, he had the sad privilege of going to war, where he saw the human animal stripped of his social check-reins.

He has thus been able to observe man under many different aspects. He has known saints, both religious and atheistic; despicable creatures who were respected; intellectually dishonest scholars; incompetent engineers; simple workers who had genius in their manner. He has seen officers and men tremble in the face of the enemy, others who sacrificed themselves with enthusiasm.

For a long time he has wondered to what extent man was really perfectible by education.

Probably his knowledge of man would have remained very superficial if he had not had the exceptional good fortune of meeting Alexis Carrel, of becoming his friend and for many long years his collaborator. When the French Foundation for the Study of Human Problems was created after he had outlined its organization during a stay on Saint-Gildas island, he became its vice-regent in charge of scientific research. The other vice-regent, their mutual friend Dr. Gros, seconded by Dr. Ménétrier, was charged with administration and the human problems. From 1941 to 1944, he devoted most of his time to this work which seemed so full of promise despite the usual vicissitudes of starting something new.

Fate was not kind to the enterprise. But this is not the time to recall the circumstances of the disappearance of the Foundation and of its regent, Alexis Carrel, who, having left his easy life in America to place himself at the disposition of his unhappy country, died of a broken heart.

France lost a fine opportunity to insure the perpetuity of her

intellectual and humanitarian mission by abruptly stopping the work of Dr. Carrel. The quest for means of procuring more and more superior men is a tragic necessity if the apprentice sorcerer is to dominate his work.

As a result of his experience and the studies he directed at the Foundation, the author believes he may be useful to all persons with human responsibilities, if only on the family level, by publishing this synthesis on the respective influences of heredity and environment and, therefore, on the conditions of forming a personality.

He serves on the councils and boards of examiners of a number of large schools and he never tires of urging the teaching of this science of man, more essential to our future leaders than technical knowledge. On various occasions people have objected to the lack of source material. This book, complemented by a glossary and a bibliography, was written partly to fill this lack, which explains its occasionally pedagogic manner.

This work comprises four parts. The first concerns genetics and heredity; the second nutrition; the third, the physical milieu; the fourth the social milieu, particularly education.

The third part has been particularly developed because, in spite of their importance, the influences of climate are not well known, as witness the paucity of the subject in the bibliography. Moreover, the author is one of the few researchers who have gone deeply into this question, and considers himself qualified to take his stand opposite the newest theories.

True, he does not make the same claim in the fields of genetics or nutrition. He is also more cautious in regard to recent works in this domain.

Although he regretfully resigned from the *École Normale,* education has always been a relatively familiar subject to him. Furthermore, he is father of a large family ("He needs guinea pigs," his sons say) and therefore has had some experience with children.

The scientific precision of this book diminishes progressively from start to finish, because the role of the psyche is in-

creasing, and while intelligence is becoming measurable, its quantitative determination is still in its infancy. Nevertheless, recent studies permit us to give in conclusion an approximate evaluation in figures of the relative psychic importance of milieu and heredity, clearing the way to new research of tremendous scope.

It occurs to the author that this book may seem tainted with authoritarianism. Any chief who after forty years compromises with his state duties proves that he has no love for man, especially for the humble and the children, who generally have such great need of support by a rule without softness.

Prefatory Note

This book is based upon the fundamental hypothesis that man is the resultant of the joint action of all environment—physical (climate and geographic), chemical (nutrition and respiration), and psychic (education and social)—upon hereditary patrimony.

Strictly speaking, this listing is incomplete, for it should include the unknown factors, particularly the possible spiritual influences, including conscience, to the extent that they are not included in the elements above, and transcendental interference. This reservation may shock the materialists, and yet this is the only true scientific approach.* In any study of all phenomena, the enumeration of the factors involved is linked to

* When *Man the Unknown* was published, a well-known biologist accused Carrel "of hesitating between Claude Bernard and Lourdes." To deny or ignore that which escapes us is antirationalistic. On several occasions Carrel has told us in substance: "I have spent my life in studying wounds. Cicatrization usually follows a general law that is quite well known. In some cases, however, under influences that are not well understood, particularly psychic shock or a special state of mind such as that induced by prayer, a wound will heal in a few days or even more quickly, instead of the month or more usually required for scar tissue to form."

the state of our knowledge. How much truer this is when the phenomenon in question involves a thinking creature with his own free will!

The vitalists will rush to object against any pretention of submitting man to determinism, of applying to the mind the rules which are valid for the material sciences. This objection deserves elucidation.

First of all, contrary to current opinion, determinism is not essential to the human spirit, for primitive man, with his naïve belief in the permanent intercession of the supernatural, is not a determinist. On the contrary, determinism would seem to be an experimental triumph, suggested by early discoveries in astronomy. In any case, its fruitfulness in the study of physics and biology does not sanction its ex-officio extrapolation into all phenomena subject to observation. The position of the scientist who has not gone over to mechanism should be the following: he postulates determinism in all the life phenomena he studies, except the advent of determinism. Aside from that he is perfectly free to believe in transcendental influences in whatever has not yet been reduced to the level of our scientific knowledge or is outside the limits of our means of measurement.

Certainly the constant progress of determinism has rallied a goodly number of biologists to become mechanists. But is there not here a professional distortion due to the fact that this working hypothesis has little by little through usage grown to resemble a necessary truth?*

* From this point of view the last poignant pages of Jean Rostand's *La Vie et ses Problèmes* are characteristic. In his admirable style, this savant expresses his anxiety over "the arid message of science," which induces the belief that "the human adventure" connives at no "eternal policy." He concludes: "Arduous, overwhelming, oppressive truth. Among the zealots themselves there are some who do not yield to it without distress. Of course, they can hardly do otherwise but to remain faithful, but there are some who must envy those who are not prevented by the shape of their minds from conceiving another shape." The phrase "the shape of their minds" seems to be the nub of the question.

But let us return to determinism on a psychic level. Were there none, it would obviously be futile to try to understand humans. It is a tried fact that some men are capable of foreseeing with some degree of probability the behavior of others in certain fixed conditions. Moreover, the fact that identical twins raised in identical conditions have the same reactions proves the existence of psychic laws.

But the number of variables involved is so great that here again, even more so than in physics, there is reason to speak of "determinist statistics." Not that determinist statistics imperil the existence of determinism, as some physicists believed several years ago. Indetermination, as Einstein observed, does not mean that precise laws are beyond achievement, but that this precision is not yet accessible to our present means of investigation.

In conclusion, we should say that this study is necessarily deterministic. The author has tried to remain within the strict domain of science and statistics, leaving to the philosophers the leisure to decide between vitalism and mechanism—a decision heavy with moral consequences and a gratuitous one at the present stage of human knowledge.

In brief, it will be admitted in the course of this book that the formation of man is the result of the combined influences of physical, chemical, and psychic milieu upon man's hereditary potentialities, without need to worry about the origin of all things and without seeking to know if science may justify or invalidate the belief in an "eternal policy."

Introduction

Twenty years, heavy with history, have flowed past since the publication of *Man the Unknown.* The cry of alarm launched by Alexis Carrel has echoed widely, for the book has been translated into a score of languages. Its success is all the more surprising since the author had great difficulty in having it published in the first place. The manuscript evoked little interest among publishers, confirming the theory that the most intimate thoughts and profoundest aspirations of men are generally ignored, especially by those who should know them professionally.

Now we have come to understand the success of the book. By a kind of premonition, the average man has felt vaguely and uneasily that our civilization might very well end in an immense disaster. For just as wild animals feel a foreboding of danger, so do simple men who have maintained sufficient instinct—some may call it common sense—discern the roads leading to ruin.

Curiously, the work was rather coldly received in intellectual circles. Certainly the personality and independent spirit of Carrel were not strangers to the intellectuals, but probably men who are essentially intelligent do not always feel, as do

the more humble, all that is inhuman in this civilization which they themselves have built.

For most readers the book was a revelation of the vague thoughts and diffuse fears which rose from the unconscious into clear thought. Carrel, with his heart, his scholar's intuition and his clinical sense, had already diagnosed the latent ailment. The shock of the events since the start of World War II has caused the disease to declare itself and it is now moving rapidly toward a climax. The prodromal disquiet which grew aware of itself during the reading of Carrel has become an acute anxiety. How can men maintain any semblance of serenity in the face of the impossibility of finding a satisfactory social system; in the face of the brutal struggle of ideologies, all equally false in their absolutism; in the face of the animosity if not the hates between nations, even between classes of the same nation; in the face of, finally, the growing power of our means of destruction which may be unleashed at any moment? Our era, by its fatalistic despair and resignation, is strangely reminiscent of that of the year 1000. Whole peoples have lost their taste for life and action, since they have ceased to multiply.

But Carrel also diagnosed the primary cause: by a strange oversight, man has lost track of the fact that the highest purpose of any civilization is man himself, and that whether a civilization is good or bad depends upon whether it makes man better or worse. Happiness is a very personal thing. It is only a reflection of the quality of the soul. Since the beginning of mankind philosophers and thinkers have pursued the mad and sterile dream that man may achieve happiness by way of society. True, the importance of environment is unchallenged. If all men were courageous, just, and charitable, it would not matter whether the regime was that of the benevolent despot, so admired by the philosophers of the eighteenth century, or anarchy in which each citizen would act freely according to the dictates of his conscience.

Judging by the moral values of a people at any given mo-

ment, it is probable that one political system is more opportune than the others. But to build a social system in abstracting the moral worth of each individual is like erecting a big building in total ignorance of the materials of construction. The persistent illusion that man may achieve happiness by heteronomous means, whereas happiness is essentially of autonomous origin, has resulted in the ballet of political regimes which France has given as a spectacle to the world since 1789: the republic succeeding royalty, only to be disqualified and give way to the empire, which in turn collapsed to the advantage of the same abhorred monarchy which returned to the cheers of the same people who had screamed its hate twenty years before. A new revolution brought in a more liberal monarchy, which yielded to a republic, which gave way to a new empire which in turn bowed out before the same republic —which had seemed so fine under the empire!

All this would be without grave aspects if the farce did not have its tragic side. Many zealous men are executed in the name of high principles, only to be posthumously rehabilitated when their ephemeral conquerors, just as ardent as they, are led to the gallows or the guillotine. And the cycle begins again, with its waste of energy and its squandering of generous men come from every philosophic horizon.

True, some countries like Britain enjoy a greater political stability, not by the excellence of the regime but by the worth of their citizens, perhaps partly due to the power of tradition. Any weakening in tradition is certain to be followed by social disturbances.

Have the colonial powers ever reflected upon the heavy responsibility implied in their introduction of white civilization into communities then in a state of social and religious equilibrium? The tribes "liberated" from their "savage state" are disappearing with frightening rapidity.

Were politicians of today aware of the wisdom of the manners and social customs of the Gauls, and the part women played in these primitive societies, they would be less inclined

to pass harsh judgment on these "barbarian" regimes which would have little to learn from the most modern political systems.*

Ignorant of its true nature, the white race has believed that the solution to the question of happiness lay in the immoderate satisfaction of its needs and of its immediate pleasures. And since life exacts extra effort as compensation for its pleasures, man has used his intelligence to cheat nature.

By an aberration which weighs heavily upon us, man has believed that his intelligence was all-powerful because it has permitted him to conquer the material universe and therefore freed him from moral law. Because he has ceased to be master of his destiny and has even lost control of the material universe he has created, he has been compared to the apprentice sorcerer. But the cause of the evil is less a bankruptcy of the intelligence than a moral collapse. For things are good or evil only to the extent of the use we make of them.

Moral values have come to be more and more disdained. All examinations and competitions for accession to the major posts offered by society are judged only by intelligence; all else is sacrificed. Moral formation is neglected when it is not held in contempt, for modern man is too intelligent to submit to any laws save those of his own good pleasure! Educators are preaching in the desert. Men who try to swim upstream are greeted only by indifference. And when, animated by a holy zeal, they dare raise their voices, they are taken to task by those whom they disturb.

Humanity is in a state of mortal sin and it is against itself that humanity has sinned. Our anxieties might be only "thinkable" if the men who hold the fate of humanity in their hands had the moral purity of the first Christians, of Saint Vincent de Paul or Saint Francis of Assisi, or, to cite more recent examples, of Louis Pasteur, Mohandas Ghandi, or Albert Schweitzer.

Undeniably intelligence is more and more necessary to domi-

* See Henri Martin's *History of France*, Vol. I, Boston: Walker, Fuller and Co.

nate the universe, which has been rendered more complex as it has been shrunk by man. But intelligence alone, dissociated from moral sense, leads to bankruptcy. The true meaning of moral sense, either religious or profane, is to respect the laws of nature which, indifferent to our illusions, may scorn our revolts to triumph inexorably in the end.

The day when every man will have the courage and the humility to recognize that he is the artisan of his own misfortune instead of accusing others or events, humanity will be on the way to a better future.

The living species cannot progress except by selection, preceded or not by mutation. Right now, as far as humans are concerned, we are progressing backward. Not only are the weak and defective artificially kept alive until the age of reproduction instead of dying in childhood as they would naturally, but the most gifted seem to have lost their taste for life, judging by the infertility of the intellectual and ruling classes. Sexual selection also works less freely, and unions are governed more by convenience and social conventions than by natural attraction.

Discoveries which were apparently happy ones, like those of Pasteur, have ironically accelerated this reverse selection. Since epidemics no longer absorb surplus population, men have found no other remedy than war; that is to say, periodically mankind is divided into two camps—the cowards and defectives who stay home to reproduce, and the strong and the brave who go out to kill each other.

The very idea that humanity is regressing shocks most civilized men. A recent book* developing this thesis caused an uproar, although it contained numerous sound ideas, despite its questionable form. The average citizen is in fact obsessed since childhood by the refrain of man's political progression. He is convinced that twentieth-century man is superior in all points to man of the last century or at least of the last millen-

* *Regressive Evolution* by Georges Salet and Louis Lafont. Paris: Editions franciscaines, 1943.

nium. It is like affirming that the present directors of the big automobile firms are necessarily more intelligent than the first inventors because modern cars are more perfected. Men who devote themselves to research know that they must unfold great intelligence to discover conjunctions or laws which will appear evident ten years later when they have been incorporated into the habit of thought.

Furthermore, modern man, imbued with transformism, can not easily conceive that this progression from bacterium to man may well be interrupted, and that a temporary regression may actually be the origin of new mutants superior to the present stock—just as some saints were first debauchees.

We cannot deny that life at this point has evolved toward the complexity and ascent of the mind, and we are tempted to agree with Carrel that this may mark a trend.*

When we realize that man has been on earth for a scant million years, the primates for twenty million, the first fishes for one hundred thirty million, we could well admit that for five hundred years or even a hundred centuries, humanity may go through a temporary regression in relation to its origins.

If there is actually a regression, at least in the white race, it may be due either to a decrease in the quality of births or to defective postnatal development.

Wild animals instinctively follow natural ethics, respecting the laws of life which lead them to beauty and natural happiness, because they "play the game." It is in fact a vital necessity, for if a species departs from the laws of nature, it disappears either by biological inferiority or differential fecundity.

By extrapolation, Rousseau decided that human nature was

* In *Human Destiny,* Pierre Lecomte du Noüy believes in a current stabilization of evolution. This hypothesis seems more gratuitous than ours. In fact, why would not the mollusks of the Mesozoic Age (the Triassic ammonite) have found that nature could devise nothing more perfect than a work which solved so happily the problem of housing and permanent fortification? In all probability we should consider ourselves as links in the long chain of evolution which goes on and on without our awareness.

good and that it should be left alone. And modern educators who would let the child develop more or less freely refer to his *Émile.*

It is very probable that the moral sense was innate in the first men living in a natural state and may have accounted for their biologic success, but Rousseau's postulate is no longer justified by observation, for evolution and civilization have certainly attenuated if not abolished this moral sense.

If Rousseau had not been imbued with the doctrine of separation of the physical from the psyche, his mistrust should have been aroused by a few simple observations: while animals are born with the ability to swim, man must relearn the art of keeping afloat and of locomotion in the water. He must likewise rediscover those moral rules which once were part of the life instinct but of which we have lost the exact meaning. The example is not an isolated one. We no longer know how to protect infants efficaciously from the climate; newborn babes die of cold or overheating, while animals know instinctively how to guard their young against such accidents, either by the construction of their nests or by their season of procreation. (This point is discussed in Part Three, Chapter VI.) We have even lost the concept of a diet balanced both in quality and quantity. We should put to work our intelligence and its effective tool, scientific research, to rediscover what wild animals know naturally. Luckily we still have the humility to recognize the fact that we must learn all over again by hard work, without being conceitedly satisfied with superficial opinions on essential questions.

It is true that just as man has perfected his natural swimming so that he can move more rapidly through the water than terrestrial mammals, so should he use his intelligence to improve his living conditions to better protect himself against nature. But he must first understand that to dominate nature he must obey nature's laws and proceed with extreme caution because of the sometimes unforeseeable and distant consequences of his acts.

The sense of beauty in early man, demonstrated by the admirable frescoes and sculpture recently discovered, has also diminished. This is not surprising, inasmuch as beauty and morality are closely linked, as childhood shows us. Strangely enough, physical or moral beauty evokes nostalgic yearning in civilized man, as demonstrated by the sensitivity of the most rustic of rustics to feminine beauty, as well as by the radiance of pure souls who by their very presence affect the most debased creatures.

Modern man recalls a foundling child or a victim of amnesia who as a result of shock or injury has lost all memory of his origin and identity. Able investigators try by questioning and deduction to determine who he is, where he comes from and where he should be going. But they grope their way, make mistakes, try to return the unfortunate to the wrong family, begin again and perhaps err again. The unfortunate may die without ever again seeing his native heath. And yet he remembers a marvelous land where all is beauty and calm and where all his troubles would end. The nostalgia of Mignon in the admirable verses of Goethe symbolizes all human aspirations for a paradise lost or half-glimpsed.

If this physical or moral beauty had not previously existed in early man, could we conceive of the relative unity of concepts within the same race? If these esthetic aspirations were purely arbitrary, there would not be the almost unanimous admiration for the same plastic or moral beauty. They are part of man's nature. Probably they have become diluted by crossbreeding and mutation, to reappear from time to time according to the laws of Mendel.

It is appropriate, therefore, that we should try to discover why the moral sense has deteriorated and how it may be restored. The problem is certainly not new, and it is probable that in the declining years of now-defunct civilizations, the philosphers and thinkers have sounded the same warnings. But we, thanks to the work accumulated by the intelligence of previous generations, have an advantage over them. They be-

lieved that moral recovery could be accomplished only by morality itself. In other words, only the spirit could heal the spirit. Happily, we have been freed from the surviving authority of Descartes' error. We know now that moral sense is not a function of the psychic milieu only, but of the physical milieu as well, and probably—through dietary habits—of the chemical milieu also. Some foods make a man good and courageous while others undermine these virtues. True, our knowledge in this field is still very superficial, because to date these human problems have interested only a limited number of scientists. But in research we do have the means, if we decide to use them, of discovering in a few decades the cause of the dwindling moral sense in white civilization and how it could be rapidly restored.

The unity of the psyche and the physical is so alien to our habits of thinking that we should perhaps dwell upon it further. Each of our thoughts or sentiments corresponds to a fixed chemical composition of our various organs or body fluids. Just as physical exercise develops the appropriate muscles, so does repetition of a thought or a sentiment strengthen the aptitude of the body to entertain or to generate that thought. Better yet, familiar sentiments impress their mould on the body and on the features, which is the reason an old man's face reflects his personality so accurately. The man trained to reason logically has a brain and other organs of different chemical and physical make-up than the man who is merely intuitive. There is no doubt that all this is linked to the endocrine system —so women reason differently than men. True, differences between individuals are partly original, but they are also acquired. They may be maintained or they may disappear according to the continuity of physical, psychic, or dietary habits. For example, certain dietary deficiencies will make a man vicious, as will be discussed in Part Two, Chapter V; likewise lessons in ethics and especially living examples of goodness and generosity will generally make him a better man.

Incidentally the physiological mechanics is of little impor-

tance here. That is to say that thoughts, either spontaneous or stimulated from without, may influence the organism to elaborate the chemical elements which condition psychic behavior, or they may husband or valorize the corresponding elements from the diet. In a word, to be accessible to certain thoughts or feelings, the body must make appropriate chemical and physical arrangements. This may explain the communication of thoughts, the indisputable cases of healing by suggestion or prayer, as well as inspiration, either transcendental or of internal origin.

Improvement of man thus depends upon proper nourishment and a favorable social and psychic environment. It is futile to try to mould the brain or the heart without regard to their physical and chemical constitution.

For all this we must know man, as well as the laws governing his growth and formation. And their comprehension should be as synthetic as possible, not limited to any single aspect of knowledge, for the various sciences have come to divide up the different activities of man, considering each as a unit itself, without relation to the others or to the whole. Just as the researcher who sees only animal tissue under the microscope cannot know the elephant, so the biologist or the psychiatrist or the dietitian knows only one aspect of man.

We need a view of man in the ensemble which will restore to him his integrality, and which will take cognizance of the interaction of his various aspects: the moral on the physical, the physical on the moral, and nutrition on the body and soul. We must therefore sketch man as a whole as seen by the various sciences together. The sketch will be difficult, but we must attempt it, however rough and imperfect it may be. Just as a sculptor attacks his formless block with great strokes of the chisel to model the basic features of a man. It will be fortunate if, through the reading of this book, men recognize themselves, learn better to recognize themselves, and especially to understand each other. For charity demands first of all mutual understanding.

Certainly this sketch can be retouched by better artists as our knowledge gradually increases. But in the twenty years since Carrel first launched his appeal, this synthetic approach has never before been attempted, to the best of my knowledge.

And since we are obliged to start from a rough draft, we will attempt this synthesis, basing our writing only on the facts of observation with constant concern for scientific exactness.

I *Genetics and Heredity*

1 ⁎ GENETICS

I

Conception : The Ovum and Spermatozoon : Genes and Chromosomes : Chromosomal Reduction : The Role of Accident : Embryonic Life and Growth

Such single-celled organisms as the amoeba reproduce themselves by the simple expedient of splitting in two. Other lower forms of life are also asexual, and although somewhat more advanced in the evolutionary scale, each specimen is sufficient unto itself for procreation. The unfortunate creatures are thus deprived, by their inferiority, of sentimental complications and the consolation of being able to blame their troubles on the opposite sex.

Man, on the other hand, is the result of the fecundation of an ovum—the roughly spherical female generative cell, about one-fifth of a millimeter in diameter—by the spermatozoon—the male generative cell, shaped like a microscopic tadpole about one-twentieth of a millimeter long.

Hereditary factors are transmitted by the chromosomes, elements of the nucleus of the egg thus formed. Each chromosome

is made up of a necklace of even smaller particles called genes. Each gene measures about one ten-thousandth (.0001) of a millimeter. Like all human cells (except the generative cells), the egg comprises forty-eight chromosomes, grouped in twenty-four pairs. Twenty-four chromosomes are furnished by the ovum, twenty-four by the spermatozoon.

Each generative cell thus contains only half the normal number of chromosomes in other cells. The process by which one of each of the normal twenty-four pairs of chromosomes is eliminated when the generative cells are formed is called "chromosomal reduction." It is also the process which determines the differentiation between individuals, for the reduction is apparently accomplished by chance. The number of combinations is considerable and two generative cells from the same individual may have points in common and points of divergence varying from complete identicalness to total difference.

Since each procreator carries within his normal cells twenty-four chromosomes from his father and an equal number from his mother, it is mathemically possible that he may transmit in his own generative cells the chromosomes exclusively of his father or exclusively of his mother. Practically, however, such a case is unlikely, and the characteristics of both parents are usually transmitted in varying proportions.

Although our present knowledge of genetics leads us to believe that chromosomal reduction takes place by chance—or, to use the mathematical term, according to the laws of combinatorial analysis—we must use the word "chance" in its most objective sense, for it is quite possible that some law we do not yet know of determines how half the genes are eliminated.

Accident plays another part in the formation of the egg. Although the mother usually carries a single ovum, the generative act exposes the ovum to millions of spermatozoa, all differing in their chromosomal make-up. Whether the man thus conceived shall turn out to be hero or coward, genius or simpleton, may—if the father's heredity contains opposite characteristics

—depend upon which of the myriad spermatozoa penetrates the ovum.*

Even if the old concept of "blood" as the agent of transmitting hereditary characteristics is only figurative, it is nevertheless true that every living being survives by half in his descendants. Certainly each of the physical and psychic characteristics can only be the half-sum of those of father and mother, for each hereditary factor depends upon a varying number of genes, both from father and mother, reacting together not as a mixture but rather as a chemical compound.

From the moment the ovum closes upon the penetrating spermatozoon, the hereditary patrimony of the creature just conceived is definitely fixed. And the congenital role of the parents is over once and for all.

While there is no argument that the biological action of the father is thus terminated, many laymen believe that the mother may still transmit to her future child something more of herself during the period of gestation. Science (at least today) says

* The thought occurs that the spermatozoa may be drawn to the ovum by some more or less complicated tropism. In this case, it is possible to suppose that the race would belong to the best spermatozoon—or at least the better spermatozoa. And we are reminded of the nuptial flight of the queen bee.

Many biologists reject this hypothesis and believe only in the theory of chance. It would then be necessary to define chance as the sum of all causes still unknown, for there is no reason to believe that the choice of spermatozoon is not subject to some sort of determinism, however complex. Some mechanists take bitter delight in the idea that man in his conception is the fruit of blind chance, that he is merely one of some two hundred billion possible permutations between paternal and maternal chromosomes.

This conception seems to me incompatible with the postulates of determinism. Man thus conceived is exactly the man he should be, that is if *all causes* were strictly identical (as far as this may have direction), the same spermatozoon would always be chosen. It goes without saying that some causes may never be known in their totality. But since we do not know, I prefer the expression "laws still unknown" to the gratuitous and discouraging "chance."

no. That does not mean that the behavior of the mother is unimportant. Far from it. For the mother's warmth and nourishment condition the development of the embryo beyond its hereditary patrimony. Better yet, her moods affect the development of the child's strength. So pregnant women do perhaps have the right to be spared all vexations and disappointments.

Barring accident, the ovum thus fertilized will produce a man two hundred sixty-eight days later. The egg will remain in one of the Fallopian tubes for the first week, then will pass into the uterus to be bathed and sustained by nourishing blood until the formation of the placenta gives it access to the mother's oxygen and nourishment.

The egg begins to develop a few hours after fertilization, first dividing into two cells, each of which then splits into two more, the multiplication continuing until the total reaches the twenty-six billion cells of the newborn child.

The chromosomes of the mother cell divided so exactly that the new cells receive the exact inheritance as the egg, except, naturally, for the generative cell to be formed later, which will lose half its genes through chromosomal reduction.

From a somatic point of view, therefore, the body may be considered as an amplification of the same single cell, since by this equitable and regular division the chromosomes of the egg are duplicated in every other cell of the organism, even in the germinal cells up to the point of reduction.

About two months after fertilization, the embryo has become a fetus measuring roughly three centimeters and taking on more or less the form of a human being. In the meantime it will have assumed some temporary characteristics reminiscent of the features supposed to have come down to man from his distant ancestors through evolution. In fact, in some measure the development of the egg during the period of gestation reproduces the entire cycle of evolution, from the unicellular protozoa to man.

After birth, the rate of growth is less rapid, and is accom-

plished both by the increase in number of cells and in their size. The relative proportions of the different organic systems undergo change. The child is more receptive than dynamic and as he grows, his muscular system develops while his digestive, respiratory and nervous systems becomes comparatively less important. After forty years, vitality decreases and old age begins with the atrophy and sclerosis of certain tissues.

The most striking characteristic of man's formation is its slowness. During his twenty-five years of growth—more than one-third of his probable life span—man is receptive. During this considerable fraction of his existence, he may accumulate not only his own experience but the knowledge handed down by his forebears. While the anthropoid apes, who when young often exhibit the intelligence of a child, become adult at the age of ten, the nerve cells of man do not reach maturity until nearly thirty. As Lucien Cuenot said, "Man is slow in growth and retarded genitally . . . (but) is well served by his incomparable prehensile hands which have given him a new source of progress in the manufacture of tools." To these exceptional gifts we may add that of a larynx which can articulate and create the conventional sounds that make up language —vector of ideas and experience which constitute the physiological superiority of Man over the anthropoids.

All this gives us an inkling of the importance of both manual and verbal education in the formation of Man.

II

The Mendelian Laws of Heredity : Dominant and Recessive Characteristics : The Eyes : Multiple Factors : The Skin

Let us return to the egg. As the child received half his chromosomes from the father and half from the mother, a knowledge of the total heredities of the two parents should indicate the

potential characteristics of the offspring—if we only knew how the elimination of half the parental chromosomes was effected.

Certain characteristics thus transmitted are independent of the environment in which the child will grow up and become a man—the color of his eyes and hair, for instance, discounting temporary discoloration by the sun. Others, such as the color of the skin, are malleable and may undergo more or less profound changes according to surroundings.

The transmission of the genes, which regulate a predetermined character, follows the Mendelian laws.

The classic example is that of the color of the iris. Mendel's observations and conclusions, confirmed by later research, classify hereditary characteristics as dominant and recessive. That is to say when a man receives two different genes governing the same physical attribute, one must always dominate while the other withdraws. The case of blue eyes and black eyes illustrates this point. If a man carries two "black-eyes" chromosomes* in his inheritance he will naturally have black eyes, and if he carries two "blue-eyes" chromosomes he will have blue eyes. But "black-eyes" are a dominant characteristic in relation to "blue-eyes." So if a child inherits "black-eyes" from one parent and "blue-eyes" from the other, his own eyes will be black.

If a man bearing two "black-eyes" chromosomes unites with a woman bearing two "blue-eyes" chromosomes, all their offspring will have black eyes, thanks to the inevitable and dominant "black-eyes" chromosome of the father.

If both parents have "blue-eyes" chromosomes, their children can have only blue eyes.

If one parent has two "blue-eyes" chromosomes and the other has one "blue-eyes" chromosome and one "black-eyes"

* Strictly speaking, we should say *genes* rather than chromosomes. But in this simple case the color of the eyes depends only upon the genes from the same pair of chromosomes. Thus it seems preferable to use the term *chromosome* to better demonstrate how the color of the eyes is linked to the chromosomal reduction in a single pair from each parent.

chromosome, their children will be one of the following four combinations:

Two children will have two "blue-eyes" chromosomes, and thus have blue eyes.

Two children will have one "blue-eyes" chromosome and one "black-eyes" chromosome; and both will have black eyes since "black-eyes" are a dominant characteristic.

If each parent carries one "black-eyes" and one "blue-eyes" chromosome, the four possible chromosome combinations in their offspring are the following:

Black-black
Black-blue
Blue-black
Blue-blue.

Out of four children, therefore, three will have black eyes and one will have blue eyes.

Absence of a dominant characteristic is easily certified. A man and a woman with pure blue eyes certainly have no "black-eyes" genes in their make-up and consequently can produce only blue-eyed children. But the blue must be very pure, without a trace of green or gray.

Of course the above ratios are valid only statistically. The proportions will be found true only in examining a large number of cases. When both father and mother carry mixed chromosomes, it is quite possible for them to produce a succession of blue-eyed children or of several black-eyed children.

The question becomes more complicated when a single characteristic, like the color of the skin, is governed by several genes.

A pure Negro, man or woman, carries three pairs of "black-skin" genes. A pure white carries three pairs of "white-skin" genes. If a Negro woman unites with a white man, their offspring will carry three "black-skin" genes and three "white-skin" genes. The offspring's own color will be intermediate, for neither skin color is dominant. If the offspring should unite

with another mulatto with the same gene inheritance, the number of possible gene combinations in the resulting offspring is extremely high. At one end of the scale the child would carry three pairs of "white-skin" genes while his brother at the other extremity would have three pairs of "black-skin" genes. In other words, the white grandparents and the Negro grandparents would be reproduced exactly. The probability that one of the two brothers should be pure white and the other pure Negro is, however, 1 in 64, for there are sixty-four possible combinations of the genes involved. The intermediate cases would have skins varying in color according to the proportion of genes.

In this respect, I must here refute certain popular beliefs. The union of a white woman with a man of some darker color cannot, as has sometimes been claimed, produce a pure Negro child. At the most, the child would be *café au lait,* for he would always inherit at least three "white-skin" genes from his mother.

Since genes of the same chromosome are transmitted as a group, it must be assumed that they follow some pattern within the chromosome. A deeper knowledge of their distribution would allow us to plot their relationship and predict certain factors, something which unfortunately we cannot do now. All that science can tell us at present is that certain genes are not transmitted independently of others.

Whatever may be the truth, it is probable that both physical and psychic characteristics are determined by several genes in combination—which explains the complexity of heredity.

Improved knowledge of the laws of heredity would thus give us a clearer picture of filiation, a revelation which might disturb the peace and quiet of some marriages. Luckily, recessive characteristics are rarely pure on both sides of a union in regions where dominant characteristics are common. In the north of France and in Flanders, for instance, pure blue eyes

are exceptional today. In the course of history, too many Spaniards have passed that way.

III

The Determination of Sex : Chromosomes x *and* y : *Ratio of the Sexes : Characteristics Linked to Sex*

It requires no great wisdom or discernment to say that differences between the sexes stem essentially from the nature of the reproductive glands—the source of ova in women and spermatozoa in men. They are manifested in other ways, too, in the secondary characteristics which are concerned directly or indirectly with reproduction—the external sexual organs, for instance. However, these are not always normally developed and many a supposed girl has grown up to be a man.

Sexual differentiation is determined at the moment of conception. Every cell in a woman's body contains a pair of *x* chromosomes. Thus each ovum contains, by chromosomal reduction, one *x* chromosome. The cells of a man, on the other hand, contain an asymmetrical pair in each: one *x* chromosome and one *y* chromosome. By the process of reduction, therefore, every second spermatozoon will contain an *x* chromosome, every other one a *y* chromosome.

Union of a spermatozoon containing an *x* chromosome with the ovum will therefore produce an egg possessing two *x* chromosomes—and the egg will automatically produce a female. Conversely the *y* spermatozoa will make an *xy* egg—automatically male. Certain biologists question the existence of the *y* chromosome. Others claim to have identified it and say it measures fifteen ten-thousandths (.0015) of a millimeter in length, as compared to five thousandths (.005) of a millimeter for the *x* chromosome. This, however, is of little importance, as long as we know that the male cell contains only one *x* chromosome.

According to the laws of combinatorial analysis, the sexes should be reproduced in equal numbers, since in principle there should be as many spermatozoa containing *x* chromosomes as *y* chromosomes.

Whether actually more *y*-chromosome spermatozoa are produced, or whether by some chemical superiority the *y* chromosome spermatozoa are more efficient, the fact remains that one hundred twenty male eggs seem to be formed for every hundred female eggs. The male embryo, however, seems to be less rugged than the male egg, for birth statistics indicate that there are only one hundred five to one hundred nine boy babies born for every hundred girl babies. This proportion, as we will see later, seems to be linked to environmental conditions, for a rising curve of excess male births is generally a sign of the physical deficiency, if not degeneration, of a population group.

It would seem then that sexual characteristics are governed essentially by *x* chromosomes, whose genes are oriented toward femininity, while the genes of the twenty-three other pairs of chromosomes in the human cell tend toward masculinity.

Therefore a man is a man simply because he has but one *x* chromosome. If he had two, he would be a woman. In a word, every living being has within itself the potential characteristics of both sexes in a simple variable proportion. This may explain why the differentiation between the sexes has no guarantee of continuity—except, of course, for the external appearance of the genital organs. There are women who are more virile than some men, and men who are more effeminate than some women.

It is disturbing to think that the equilibrium between the dominant sex and the submissive sex may be upset by outside events. A deficiency in diet—qualitative and quantitative—may destroy the harmony of the hormones. During World War II, some Europeans starving in Japanese prison camps progressively showed signs of femininity in their voices and their bodies, signs which disappeared when they were returned to

normal diet. Injury to the pituitary gland may also disturb the endocrine balance to such an extent that men may develop more or less feminine traits.

The importance of psychic atmosphere is also well known. Just as a man thinks with all his organs, so do his thoughts react upon his entire body. In a feminine atmosphere a man will become effeminate, while a little girl raised with boys will generally become less effeminate than if she were surrounded by girls.

The "sex" chromosomes x and y contain other genes of general influence and the transmission of the characteristics which they govern is consequently linked with sex. The x chromosome in particular may contain recessive genes which a father may pass on only to his daughters. For instance, a father with hemophilia, a disease caused by a recessive gene in the x chromosome, may transmit the malady only to his daughters. It will appear only if this gene is not dominated by the corresponding normal gene of the mother. The daughter thus becomes the carrier of a repressed recessive gene and one of every two of her sons will be a bleeder, depending upon which of the x chromosomes will appear in the ovum, that of her father or that of her mother.

It has been noted that by an abnormal reduction of x chromosomes in a woman, both may appear in the ovum, so that some women may have both a y chromosome and two x chromosomes. Curiously enough, despite the oddity of this chromosomal pattern, these women display no special male characteristics. This confirms the omnipotence of the pair of x chromosomes over all others.

It has also been stated that some animals may be of a sex opposite to that deriving logically from their chromosomal pattern. Thus a male may be bearer of two x chromosomes and a female of the xy combination. The males could thus sire only females and the females should produce two males for every female, the combination producing two y chromosomes not being viable. In any event, there is no evidence that this phe-

nomenon could be produced in human beings, even though it would be very convenient to explain why some men have only daughters. The explanation is no doubt a matter of chance, or of some physiological cause which has so far escaped us.

So we find that the difference between the sexes is far from clean-cut. It may be influenced by diet, and by physical or psychic surroundings. Civilized life, with its various excitements and its stimulating artificial climates, acknowledges sexual differentiation and hurries it. The confusion of tendencies was more marked in the past, as witness the Greeks and the *mignons* of the Renaissance. Persons of doubtful sex are today more frequent in God-forsaken regions with enervating climates.

Should we consider this accentuation of sexual differences as an unadulterated benefit to civilization? After all, to understand each other, we must have points in common. And it is by no means certain that a happy blend of the sexes does not enrich the personality.

IV

Parthenogenesis and Gynogenesis : Pseudo-hybridization

A recent stage play in Paris* brought to light an extraordinary method of reproduction among bisexual creatures which so far is only of scientific interest. It would seem that it is possible, by appropriate physical treatment, to stimulate an ovum to development without having been fertilized by a spermatozoon.

The classic example of this is the parthenogenesis of a frog's egg provoked by pricking it with a fine stylet. The embryonic mortality rate is considerable but it is possible to carry the development quite far. With mammals (although it has been done with doe rabbits) the operation is obviously more complicated since it is necessary either to reach the ovum in the

* *L'Immaculée* (1947).

tubes or to remove it and replace it later in the uterus after treatment.

The development of the ovum without actual fertilization may be more conveniently accomplished by the phenomenon of gynogenesis, more recently discovered. The penetration of an ovum by a spermatozoon causes both activation and the segmentation that leads to embryogenesis. However, as explained at the beginning of this chapter, the spermatozoon also furnishes, by inverse action of chromosomal reduction, one-half the chromosomes necessary to the heredity of the child. Now these different effects may be produced separately. By that I mean that fertilization may be incomplete in the sense that the chromosomes of the spermatozoon do not combine with those of the ovum, and yet the ovum may continue to develop just as if it had been normally fertilized. This phenomenon, which is normal procedure with certain worms, constitutes an intermediate step between true fecundation and natural parthenogenesis. It may be accomplished experimentally with sperm belonging to an entirely different species. When the species is not sufficiently different, the consequent effect of chromosomal regulation results in nonviable eggs. But when there is sufficient difference, the sperm induces partial fertilization leading to viable specimens called pseudo-hybrids. The combination of the common toad with the tree frog, for instance, produces pseudo-hybridization.

The same result may be obtained with two more closely related species if the sperm is so treated that its chromosomes are rendered incompatible without destroying its power to activate the ovum. This may be accomplished either by irradiation or by refrigeration to a predetermined temperature.

The issue of these experiments thus in principle contain only half the chromosomes of the normal cell. That is why they are usually feeble specimens and rarely reach an adult age. Some of them develop normally, however, and observation has shown that their cells contain the number of chromosomes normal to the species, which leads us to believe that by some

yet-unknown process the egg has succeeded in doubling its supply of chromosomes.

It goes without saying that the issue of these experiments has been uniformly female, since it contains only x chromosomes.*

This treatment of the ovum allows us to envisage the possibility of inducing fecundation in the human species without relation to paternal heredity. Needless to say, at our present stage of scientific knowledge, the prospect is in the far-distant future. But it is still true that in certain species not very high in the scale of evolution, the females seem capable of laying eggs which, unfertilized, produce females exclusively. The parthenogenetic breed displays great fertility and little by little supplants the two-sexed breed, of which the males grow rare and finally disappear.

A mutation or exceptional environmental condition could perhaps bring realization of Alfred Comte de Vigny's dream of segregation of the sexes. But it would mean the death knell of the male.

Current ideas about death are worth considering, because biological solidarity—the physical and the psychic—of different generations is at present masked by the exaggerated concept of personality.

Potentially, man is exactly as immortal as the worm which reproduces itself by fission or the tissue of the chicken heart

* It is admitted that in special cases an ovum might preserve all forty-eight chromosomes of the cell, so that the creature evolving from this egg could give birth to a girl who would be the exact portrait of her mother. (This hypothesis is the basis for the play *L'Immaculée.*) But it is more probable that the offspring would be the issue of an ovum having gone through chromosomal reduction and a subsequent redoubling. In this case the daughter would be double the half—abstracted from crossing over—of the potential characteristics of the mother. She might be blonde with blue eyes even though the mother was a brown-eyed brunette. But the issue of the parthenogenic daughter, by the same process, would be the exact image of the mother, and after the second generation, the breed would be stabilized.

grown by Carrel outside the chicken. The only difference is that, in order to survive, man must mingle his life with that of a creature of opposite sex. This is the biological foundation of human solidarity. Retrieving the unity of the first asexual creature, we must consider that the couple is the ensemble of the human race, that the couple lives on in each of its children. Certainly the temporary framework of their successive personalities disappears and returns to dust, but does not the same thing happen to the human body during its lifetime, when its component cells are definitively destroyed to be replaced by new cells? What is there in common, physically, between the body of an old man and that of the suckling babe he once was? The most obviously disturbing things about death and life are, on the one hand, the abrupt interruption of continuity, and on the other, the necessity of restoring original vital unity by copulation.

If by parthenogenesis we someday succeed in reproducing a woman without masculine intervention, then this woman will be properly immortal. If her daughter, who will be identical with her in conception, develops in the same environment, she will be the exact portrait of the mother at any given age. If she changes environment, she will be what her mother would have been in the new environment. True, the worn-out bodies will disappear periodically, but there will always be on earth a woman or several women identical to the first. She will be the same woman in several bodies, either simultaneous or successive.

But this asexual reproduction would certainly be disastrous to the idea of human solidarity, for each human being would become forever a biological stranger to his neighbor, even more so than members of our contemporary castes, who have no biological contact with each other and who lead parallel lives like different species.

If a man is surprised not to find half of himself in each of his children, this is essentially because environmental conditions have changed, and incidentally because some of his recessive

characteristics have given way before characteristics of his partner in procreation. In this he is generally to be congratulated, inasmuch as the recessive characteristics are often of inferior quality and more unstable than dominant characteristics.

So man is really in no position to disown his children, although this might be less mortifying than admitting he had brought them up badly.

2 * ADAPTATION AND VARIATION

I

Adaptation : Lamarckism : Its Invalidation by Experiment : Mutation and Neo-Darwinism

Patrimonial heredity, determined at the moment of conception by chromosomal pattern, is made up both of characteristics which are unalterable and of others which may be molded by environment. While the color of the eyes is fixed once and for all, muscular strength may be developed by proper training.

Opinion today tends to admit that this environmental influence is more or less transmissible. For instance, the children of a man who has cultivated his intelligence will be more intelligent than if their father had remained uneducated. This implicitly admits that acquired characteristics may be inherited.

The Chevalier de Lamarck's whole theory of evolution is based upon this principle. In fact, Lamarckism supposes that environment, habit, and necessity fashion the organism for its best defense, a theory which may be essentially expressed as: "Need (fortified and amplified by use) creates the organ." On the other hand, if the organ remains useless it atrophies and

ultimately disappears. According to Lamarck, the modifications acquired by one generation could be inherited by the next and the cumulative effect would constitute orthogenesis—that is to say, continuous variation of a type leading toward the ideal form. The species therefore would achieve stability only in so far as the environment remained stable, always provided, of course, that progressive adaptation should cease. The classic example—a picture-book example, really—is that of the giraffe. Here is an animal which lives on the leaves of trees and has been forced to reach higher and higher for its food ever since it first appeared on the scene—a fact which explains its elongated neck and long front legs. In the same manner, aquatic birds, forced to swim and walk on mud in search of food, have, over the thousands of generations, formed webs between their toes.

The essential thought in Lamarck's theory is that changes of form and conspicuous modifications of the organism always follow a change of environment or of habits. It is based on the hypothesis that an organism has the power of divination regarding modifications that would be essential or at least useful. This gift of prescience, incidentally, seems to be confirmed by physical reactions in our daily life which bring about external changes. For example, the skin assumes protective pigmentation to limit the penetration of ultraviolet rays.

While it is difficult to argue the soundness of this hypothesis, which derives more from metaphysics than from biology, it is certainly possible to study experimentally Lamarck's thesis that acquired characteristics may be transmitted.

Every experiment to date has given negative results.

Some experiments have studied the possible transmission of mutilations or pathological poisoning. Others have looked to the transmissibility of acquisitions or atrophies due to climate or use, as well as psychic acquisitions due to training. While early experiments, rather sloppily carried out, gave hasty conclusions in favor of the heredity of acquisitions, later and more careful experiments have incontrovertibly proved the germ cell

to be completely independent of characteristics acquired by the parents.

Hundreds of observations were made, particularly checking on the heredity of climatic effects on insects and warm-blooded animals. The most famous were those performed by James Sumner in 1915. Similar mice were raised in different conditions, one set in a relatively high temperature (about 72° Fahrenheit), the other in distinctly cold surroundings (averaging about 36° F.). The mice in the warm room grew more slender than the cold mice, with longer ears, feet, and tails. Yet the descendants of both lots, raised at normal temperatures, showed no appreciable difference. Thus the bodily modifications were not transmitted.

There was some criticism that these experiments were of too short a duration, so they were repeated with animals bred in a controlled environment for many generations. For instance, vinegar flies kept at high temperatures from the moment of their hatching developed eyes with a decreased number of facets. The experiment was continued through fifty generations. When the last descendants were removed to a normal temperature, their eyes became normal, exactly identical with those of their ancestors who had never been subjected to high temperatures.

The heredity of acquisitions by training, sometimes called psychic characteristics, is still in dispute. It seems to have been proved by the experiments of Pavlov, who taught dogs to associate the ringing of a bell with feeding time. He found that it took three hundred experiments before dogs learned to run to their feeder when an electric bell sounded. The next generation was trained in only one hundred trials. The second needed only thirty, the third took ten, and the fourth generation got the idea after only five trials. Pavlov thereupon concluded that at the end of *x* number of generations, no training at all would be needed.

Similar experiments on rats and mice by Halsey Bagg, Edwin MacDowell, and Miss Vicari led to opposite conclusions.

In these experiments the rodents were trained to follow the winding passages of a labyrinth to find their food. The successive generations took just as long as their trained ancestors, thus apparently invalidating the theory that aptitudes can be inherited.

To sum up, we may say that with rare exceptions—and in these cases the experimental techniques may be subject to review—all experiments designed to prove that acquired characteristics may be transmitted have failed completely. And we may conclude that the genes are passed on from one generation to another without being influenced by environment.

To quote a phrase of Rostand: "As we were conceived, so shall we beget." The organism is the source of nourishment, but the germ cell, the parasite, is custodian of all its intrinsic characteristics.

An experiment with guinea pigs by William Castle and John Philipps is particularly suggestive. The ovaries of a black female were grafted into the body of an albino female whose own ovaries had been removed. The albino female was fecundated by an albino male on three occasions. The six guinea pigs resulting from the union were all black, although normally the union of albino parents produces only white guinea pigs. The six black animals were in reality the offspring of the black female who lent her ovaries to the experiment.

As we have seen, the way of life of the parents is without apparent influence on the chromosomes which pass on to the children. That does not mean that the children will not have a natural tendency to adopt the parents' habits. But if they do, it will be through imitation, natural desire, or inherited tastes. If the son of a drunkard becomes a drunkard, it is solely because both have inherited the taste for alcohol from some earlier forebear.*

* Let it be understood that we are speaking here only of the chromosomes. The somatic nature of the child depends greatly on his parents' way of life. Their behavior and their diet are important factors of the

Does it follow that patrimonial heredity must remain unchanged from one generation to another, a statement which seems to refute the possibilities of evolution? Certainly not. In man, as in all other living species, sudden unforeseen variations may appear which are instantly transmissible. Influences which are not well understood cause abrupt chemical changes, or mutations, in the genes. This change in the genes, which affects their properties, becomes stable for future generations. But while Lamarckism insists that this variation results from environment of the way of life of the soma, the mutationist sees only a spontaneous change in the germ cell.

The antagonism between mutationism and Lamarckism might be considered only verbal if the modification undergone by the genes were oriented in the direction of adaptation. But this is not the case. Scientists today believe that these mutations are purely fortuitous. Either the mutations are discouraging to adaptation, or—and this by chance happens more often—they are unfavorable to the offspring, which consequently disappears from the struggle for existence. If on the other hand the changes are favorable, then the offspring will be better fitted for survival than the older species, according to the laws of Darwinism. Thus the evolution toward the best-adapted forms may be explained, in the current state of our scientific knowledge, by a series of mutations. The worst are eliminated; the best survive to confer a permanent superiority upon the best-fitted mutants.

The antithesis of the two theories may be summed up in two lapidary phrases, both pregnant with metaphysical meaning. According to Lamarckism, "Use creates the organ." According to mutationism, "The organ creates the use." For example, Lamarck would say, "Men have eyes to see and ears to hear," and the exponents of mutationism would reply, "Men

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environment which affects the child's development even before his conception. (*See* Part II.)

see because they have eyes and hear because they have ears." There is truly an abyss between the two.

In any event, man's conception of the world depends upon his organs. If, instead of eyes, nature had endowed him with an antenna capable of receiving Hertzian waves, his idea of the universe would be completely different.

Our world, material as well as psychic, can never be anything but essentially human.

II

The Independence of the Germ Cell : The Diversity, Rarity, and Apparent Anarchy of Mutations

While the adaptation of an organism to its environment is undeniable, the process operates on two different levels. First, the soma changes instantly and directly, but the modification is not hereditary, since descendants returning to their original environment will preserve no trace of the change. Then, little by little, by mutation of the germ cell and by selection, a better adaptation takes place, which is not only hereditary but which may prevent the new generations from surviving in the original habitat of the species.

Certainly environment may act upon the impregnated female and may influence the offspring in gestation to such an extent that the new generation may be appreciably better adapted than the immigrant parents. Thus Europeans conceived and born in the colonies often show more or less distinct characteristics of the local races. This, however, is merely an act of anticipation involving the soma in formation, and has no effect upon patrimonial heredity.

In a word, the germ cell does not resemble the soma. Instead, the soma—the body with the exception of the germ cell—is an amplification of the sum of the parental germ cells united at the moment of conception. The soma has been molded by

environmental influences during the course of its formation, but the germ cell has remained untouched and the changes will not necessarily survive if the environment is modified.

The germ cell appears to be the guardian of the species, which is committed to perpetuate itself. For that purpose, it must engender new somas according to need, somas sufficiently flexible to be moulded by environment the better to survive. To these transformations, the germ cell pays no heed. It controls the soma, leaving just enough latitude for adaptation, from which it remains completely independent.

Up to this point we have alluded only to the collective mutations affecting the genes. But there are also chromosomal mutations, which consist in a change of pattern of the genes within the chromosome, or even the passage of a gene from one chromosome to another. As the action of the genes depends upon their position relative to one another, it is conceivable that profound changes in the species may result from such mutations. Furthermore, certain mutations may even induce an increase in the number of chromosomes in the germ cell. Instead of the usual two parental sets which make up the egg, some animals in exceptional cases have been found to carry three or four sets. They are distinguished from their fellows by an increased vitality. Whether similar mutations exist in man is not known. If they did, the favored individuals would have a marked advantage over normal humans.

Finally there are mutations which do not appear in the generative cells but in a body cell. If these mutations arise in embryo, they will appear in every cell engendered by the mutant cell. A certain unharmonious condition of the soma will result, inasmuch as the chromosomal pattern will not be uniform throughout the body. Some human asymmetry is attributed to these somatic mutations.

It is difficult to estimate the frequency of mutations. All we know today is that they explain neither racial nor individual differences. The most plausible scientific hypothesis is that they all stem from one couple, with successive differentiations.

One thing is certain: mutations are relatively rare. And since they are more likely to be unfavorable to the species than favorable, it is confusingly difficult to explain adaptation and evolution in terms of mutationism followed by Darwinism. So we are forced to the conclusion that at some time in the more or less distant past, mutations were more common than they are today.

It is a well-known fact that nature is never more insanely lavish than when concerned with reproduction. If the number of ova fecundated is only a small fraction of those formed, what should we say of the spermatozoa, millions and millions of which are produced for every one that penetrates the ovum to give rise to the egg? And who has not seen the yellow profusion of wasted pollen that carpets the floor of the forest at flowering time?

Why does this same loss of energy shock us in the concept of evolution? Is it because we are too imbued with teleology or enlightened Lamarckism? In any case, good sense seems reluctant to admit the mutationist explanation pure and simple, which some minds—of varying degrees of cultivation—reject as improbable.

Unfortunately, empirical evidence seems to veto the intuitive concept of progressive, continuous, and rational evolution. Contemporary geneticists would diagram evolution as follows:

The germ cell is a world in itself. When a creature is born, potential characteristics are liberated, generally varying from one individual to the next in quantity but not in quality. We may call this the hereditary patrimony of the species.

But there are potentials contained in the germ cell, other characteristics still imprisoned because the soma cannot make use of them. They constitute, in a way, the evolutionist potential of the species. They can be released only by mutation and pass at that moment into the available potential.

But mutation cannot materialize something which is not already in potential being in the organism. The evolution of the species may thus develop only within determined limita-

tions—unless we admit that all possibilities exist potentially within the chromosomes.

III

The Transmission of Characteristics : Crossing Over of The Chromosomes : Stability of Hereditary Patrimony and its Social Consequences

As the child's chromosomes derive half from the father and half from the mother, just as did those of his parents, it would seem that each of these chromosomes must have belonged to one ancestor in each generation. However, this presumes the complete independence of the chromosomes in the same pair, and an observation by William Morgan further complicates the question. Before chromosomal reduction, the chromosomes of the same pair are very close and are sometimes even entwined about one another, which gives rise to the thought that there may be some exchange between the two, so that the chromosome tapped for the germ cell may well blend the characteristics of both of its forebears. This theory of the crossing over of the chromosomes comes to confuse the part which the law of combinatorial analysis attributes to the grandparents.

Be that as it may, the customary classification of physical and morphological characteristics falls into four groups:

1) Those of mixed heredity.

2) Those of Mendelian heredity (dominant or recessive).

3) Those apparently belonging to both preceding groups—that is to say, where dominance is incomplete or imperfect.

4) Those whose heredity is linked with sex.

As an example of mixed heredity, we may cite size and weight, the shape of the head and face, even though certain facial features seem sometimes taken from one parent to the exclusion of the other, instead of being a combination of the two.

The characteristics of Mendelian heredity are sometimes pathological when recessive. The reference to pathology, incidentally, is a matter of conventional terminology. For example, there is obviously nothing morbid about the color of the eyes, caused by the more or less complete pigmentation of the face of the iris, except perhaps in the case of an albino. Be that as it may, recessive characteristics are more often handicaps than advantages.

Left-handedness, dental malformation, harelip, predisposition to bear twins, are all usually considered incomplete Mendelian characteristics. Finally, characteristics linked to sex, such as hemophilia and color blindness, are all pathological.

For mixed heredity, the crossing-over theory would tend to decrease the differences between children. Yet if there were an effective exchange between chromosomes before the chromosomal reduction, it could only be incomplete and irregular. Otherwise all children would be the exact average of their parents, whereas sometimes a child turns out to be a striking duplicate of one grandparent. Nothing bars the acceptance, however, of the possibility that this crossing over of chromosomes may arise in only one parent, and that the mixed characteristics result from the combined action of two chromosomes from this one procreator and one passed on practically pure from one of the four grandparents of the other.

This stability of patrimonial inheritance may seem discouraging to men of good will anxious to improve the quality of their descendants. The message of biology is, in fact, rather disappointing: the most exemplary of lives and the mightiest of strivings toward an ideal cannot improve the genes. The best that can be hoped for is a mutation, and since these are more often unfavorable than not, the parents have not much to expect in the way of betterment of the race. And yet common sense seems dead set against this pessimistic conclusion. The behavior and the diet of the mother certainly are of great importance during gestation, and it does make a difference whether she drinks milk or alcohol. It is even probable, as we

shall learn later, that the diet of both father and mother before conception play an important part in determining the qualities of the future child. Likewise the child's ultimate character will be reflected to a considerable extent by the manner in which he is brought up. But it remains no less true that, except in case of the comparatively rare mutation, the parents will transmit unchanged to their descendants the same genes they themselves received.

These biological facts are sometimes used as social arguments. The handing on of an acquired fortune at death from father to son may seem against nature, since biologically acquisitions may not be transmitted from generation to generation except through education, and then on dubious grounds.

On the other hand, this stability may be sound basis of hope for families and peoples in decline. Barring misalliances, their descendants will from the moment of conception be endowed with the same possibilities as their illustrious forebears. Given a suitable environment, they should logically be able to resurrect these great ancestors.

That the French people should be well fed, well educated, and well governed—so that France may again become the spiritual beacon of the world, despite the frightful blood-letting of war—was the biological dream of Alexis Carrel, and the justification for the French Foundation for the Study of Human Problems.

IV

Notes on a Famous Quarrel : Mendel-Morgan vs. Michurin-Lysenko

The classical theory of genetics which may be summed up in three names—Mendel, Weissman, and Morgan—and which explains evolution by Darwinism among mutants, was violently attacked in 1948 by the Russian Academy of Sciences. Some Soviet savants claimed at that time to have made successful

experiments proving the inheritance of acquired characteristics, which again would explain evolution by Lamarckism.

Trofim Lysenko, on the basis of his own work and on the research of Ivan Michurin, denied that hereditary patrimony has the inflexibility which is typical of Mendelian theory. By vegetable grafts and a suitable environment, the Russians said they obtained "vegetative hybrids" as against the "sexual hybrids" resulting from the exchange of chromosomes. The experiments were later attacked by other Soviet scientists and, still later, were given some support again.

It is difficult to evaluate the soundness of the Russian argument without detailed reports on the experiments in question. It was generally agreed, before the Russians went to work, that no authentic experiments had been able to establish proof for the heredity of acquisitions. This explains the coldness with which non-Russian geneticists have received the theories of Lysenko. It would, however, be unscientific to reject them without profound study. Moreover, official Soviet science is orienting much of its work toward trying to demonstrate the truth of the Michurin theory. The world of learning can only applaud, for in this way we must ultimately see the light, no matter in which direction it shines.

Proof of the Michurin theories would obviously have important consequences. Not that they might destroy Mendelianism, as it has been claimed, but they would complement it by revealing sources of variation other than mutations. But this would be a long way from rehabilitating Lamarckism, for the Russian experiments with vegetable grafts can hardly explain the structural adaptation of animals to meet movement and necessity.*

* The author would be delighted to see proof of the inheritance of the influence of environment, particularly climate, to which he has devoted so much time and research and which consequently would assume great importance.

3 * CONSANGUINITY AND IMPREGNATION

I

Consanguinity : Its Dangers and Advantages : Partial Elimination of Recessive Defects Due to Consanguinity : Impregnation

If all men are the issue of the same couple, it is obviously necessary that the children must have intermarried, yet the problem of consanguinity has been the preoccupation of men since dimmest antiquity.

Current legislation generally forbids union between close relatives and some religions have taken a position opposing marriage between first cousins. On the other hand, the laws of the ancient Persians and Egyptians allowed unions between close relatives and certain surveys made of isolated human groups, such as that on the French Channel island of Bréhat, off the coast of Britanny, seem to invalidate the need for this prohibition. Before the time of Mendel, cattle breeders had noted that consanguinity has given excellent results in some cases, disastrous in others. The laws of genetics furnish us with an explanation for these contradictions.

Every man usually carries some defect linked to a recessive gene. If he marries a woman who also carries this gene, 75% of their children will carry the gene as recessive and 25% will actually show the defect. In a union of two beings coming from different environments, it is relatively improbable that they should be marked by the same defects. If they are to some degree related, however, the probability rises sharply.

Mathematically, if we let f stand for the frequency with which the defect appears, the probability that two procreators chosen at random should carry the same recessive gene is f^2. On the other hand, if they are first cousins, there is one chance in sixteen that they carry the same defect so that the probability of reappearance becomes $f/16$. As f is generally quite small, marriages between first cousins multiply considerably the chances for the defect to appear.

This probability is linked mathematically with the degree of relationship, and a simple calculation shows that the danger is just as great in marriages between double cousins-german as between half-brother and half-sister. It is quite logical, therefore, that eugenicists should be anxious to forbid or at least discourage consanguine marriages.

J. B. S. Haldane has nevertheless drawn attention to certain consequences of forbidding consanguine unions. When the bearers of the same recessive defect intermarry, 25% of their children develop the defect and are thus excluded from the reproductive cycle either because the defect brings about their disappearance before adulthood or because their physical handicap makes them unfit, either constitutionally or by selection, to reproduce. On the other hand, if a bearer of recessive genes marries at random, half of his children bear the gene, which remains recessive and therefore causes no exclusion from the cycle. In a word, consanguinity induces 25% of the casualties to the pathological gene, casualties which do not occur when both parents are not bearers of the same recessive gene. Nonconsanguine unions thus multiply recessive defects.

It goes without saying that in pure populations in which

there are no recessive defects, consanguinity presents no eugenic danger. Practiced rationally by animal breeders, consanguine unions may usefully develop desired characteristics within a group. Perhaps for this reason consanguinity was not found offensive by early man. As one skeptical moralist said once: "If there was such a thing as pure race, consanguinity to all degrees might be a virtue."

Another long-debated question is that of original impregnation. According to some breeders, when a female has borne offspring by a certain male, subsequent litters by other males may reflect the type of the original male. In a word, the female would be indelibly and perpetually imprinted with the stamp of the original male. The theory has been extended to humans to explain that children of second marriage may sometimes resemble the first husband.

Genetics utterly destroys such claims. Yet once in a while incontestable evidence seems to justify the theory, whereas the phenomenon is actually due to the impurity of races. It is quite possible for a child to be born who resembles neither of his parents, but who may accidentally have the type of a man with whom the mother had had prior relations. According to the "impregnationists," she is supposed to bear the indelible imprint of her first male, whereas the truth of the matter is merely an example of the Mendelian laws in action: the child repeats the type of some more or less distant forebear. The union of two mulattoes may produce one pure black child and one pure white child. Should the mother have had previous children by a white man or a pure Negro, the simple Mendelian example would seem to prove the impregnation theory.

Although experiments have flatly disproved the thesis of impregnation, some biologists remain unconvinced. They say that the theory is so firmly believed by animal breeders that it must have some basis of fact. Is it not quite possible that the inevitable interchanges between fetus and mother could leave their mark on the mother which might affect future offspring?

4 ⁎ PSYCHIC HEREDITY

I

Mechanism and Vitalism : Tryon's Experiments : Statistical Research of Galton and Pearson : Uncontrovertibility of Intellectual Heredity

Whether heredity has the fixity of the Mendelian theory, attenuated by mutation, or whether it is susceptible to modification by the transmission of the acquired, as the modern Russians have claimed, there is no denying that physical characteristics of descendants are the direct consequence of those of the ancestors.

For reasons both philosophic and scientific, agreement is less unanimous in the matter of psychological heredity. Philosophers shy away because to admit total heredity would be to minimize free will; scientists, because psychological and moral observations cannot be as strictly controlled as physical measurements. For the mechanists, psychic activity is only the result of physical facts and therefore psychic heredity, despite its complexity, is just as precise as physical heredity. For the vitalists, on the other hand, science is incapable of explaining

life by simple biochemical processes. We must therefore admit the existence of some transcendent principle free of the laws of matter and consequently of genetics.

A clear-cut settlement of this question is impossible in our present stage of scientific knowledge, but we must recognize the possibilities of the mechanistic principle which, assuming the materialism of all vital manifestations, thus holds them responsible to science. In the struggle between the two theories, there is no doubt that mechanism continues to score. The vitalists have on numerous occasions seemed to triumph in the face of temporary checks and setbacks of the mechanists, only to fall back again when the mechanists succeeded. The fight is still even, however, for as long as all vital manifestations, particularly thought, have not been explained by biochemistry, we cannot accept the invalidation of free will or the supernatural origin of thought. These differences are really a question of faith, in the broadest sense of the term.

The social consequences of psychic heredity are so considerable that all political systems must postulate either its acceptance or rejection. We must recognize that most human races are organized into societies which do accept this heredity, thus giving rise to castes and social classes. But sociological evolution in the direction of democracy and the equality of men tends to negate, or at least minimize, the importance of this heredity.*

Experimentation with animals in this field presents obvious difficulties, for how are we to span the gap between their rudimentary psyches and the most subtle of human faculties? However, one experiment by Tryon is most enlightening. Common rats were submitted to the labyrinth test; that is, they were

* It may seem paradoxical that the earlier societies should be imbued with the principle of heredity, while the civilization which has scientifically proved the transmission of individual inequalities should lead to an egalitarian democracy. This is because civilization progressively domesticates the environment, and education in a measure attenuates hereditary differences.

made to cross a maze and their errors noted. Afterwards the rats were divided into groups—the clever ones which had made the fewest errors and the stupid ones which had made the most. The progeny of the two groups were similarly screened in turn, and the rats bred only within their respective groups—clever with clever, stupid with stupid. The retesting and regrouping was continued for seven generations. At this stage the cleverest rats committed an average of one hundred times fewer errors than the stupidest rats, while the differential between the two groups at the first generation was much less. Thus we may conclude that this cleverness is hereditary and selective.

Working independently of the geneticists, various psychologists have been studying objectively and empirically to what extent the same psychic qualities are found in one human family. The most striking work in this field has been done notably by Sir Francis Galton and Karl Pearson, who, although they worked during the last century, are still considered authorities.

From their comparisons, both qualitative (Galton) and quantitative (Pearson), with the use of correlation coefficients, there would seem to be a real continuity running through families, which is described by Charles Davenport in these terms:

"The result of these genealogical studies is striking. Each family seems marked with a certain number of characteristics, depending upon the nature of its germinative plasma. One family will be characterized by its political activity, another by its success in the liberal professions, another by the madness of some of its members, either with or without the brilliant qualities of other members, one by imbecility or epilepsy, another by thieving or sexual immorality, another by suicide, still another by mechanical skills or musical or literary talent."

Let us recall the classic examples: In 1900, the Edwards family numbered some fourteen hundred members with a distinguished record in the liberal professions. Five hundred of

them had been doctors, writers, ministers, lawyers, officers, college graduates and college presidents. On the other hand the Jukes tribe numbered, in 1914, twelve hundred members, of whom three hundred ten were on relief, six hundred were feeble-minded, three hundred prostitutes, and one hundred forty criminals including seven murderers. Not one Jukes had finished elementary school.*

The study of the families of famous men confirms this influence of filiation. Whether we examine the family of a musician, a painter, a writer, or a celebrated scholar, we invariably find a whole series of relatives similarly gifted.

Davenport's statistics on the heredity of musical talent are equally indicative. Of the two hundred two descendants of forty-eight couples endowed with exceptional musical talent, eighty-one were highly talented, one hundred twenty were good musicians, and only one was really bad. In four families of which both parents were bad musicians, the twenty-nine children were all bad musicians. In two hundred fifty-seven cases in which one parent was very good and the other mediocre or worse, forty-five children were bad musicians, eighty-four children had exceptional talent, and one hundred twenty-eight were average.

In defining distinction by criteria which are necessarily arbitrary though logical, Galton reached the following conclusion: "The probability of a man attaining fame is twenty-four times greater if he has a famous father, thirty-one if he has a noted brother, twelve if he can boast a celebrated grandfather, fourteen if an uncle, seven for a cousin, and three and one-half times for a paternal great-grandfather. These figures apply to the middle classes. They are higher in the upper classes and less in the lower social strata."

The thought comes immediately to mind that these rich veins of similar family talents may well be due to the influence of

* These classic examples can scarcely be conclusive, for the families came from different environments and their behavior differences cannot be laid solely to difference in heredity.

family environment. There is no doubt that environment does play a part. And yet despite their more or less arbitary character, these statistical surveys do lead to very interesting results. The correlation between mental characteristics of members of the same family is closely related to that of physical characteristics. Both seem to be similarly transmitted. This heredity may not always appear in daily life because the parents have not had the same education as the children. A great mathematician, for instance, may have a father and mother who never finished grade school but who nevertheless possessed great potential mathematical intelligence.

Intellectual gifts seem to derive from blending inheritance. The intelligence of the children is generally intermediate between that of the father and the mother.

A more thorough study of these statistics seems to show that the continuity of intellectual characteristics is more marked than that of moral characteristics. If this is true, it seems easily explicable. Despite its biological basis, morality depends more or less upon living conditions and environment, so that ethical concepts derive more from a conventional education than from innate characteristics.

This was the status of the question in the mid-1930s.

5 ✳ TWINS AND MONSTERS

I

The Cause of Monozygotic and Dizygotic Twins : Superfecundation : Superfetation : The Frequency and Heredity of Multiple Pregnancy

The already old and rather scanty studies which point to the probability of psychic heredity have since been surpassed in both technique and conclusions by a method foreseen by Galton about 1880 but not brought to fruition until 1924 with the work of Hermann Siemens. It consists in the comparison of twins. Its scientific value is certain and its possibilities enormous.

Although human births are usually single, they may be multiple, involving two, three, four, five, and even six children. The multiplicity is due to two distinct causes:

1) Two ova may exceptionally mature simultaneously, enter the Fallopian tube and uterus together, and be fertilized at the same time. Under these conditions the two children, who will be born together, will be neither more nor less than ordinary sisters or brothers. Even though they will be born simul-

taneously, they will have different chromosomal patterns since they derive from two ova and two distinct spermatozoa. They may be of different sexes; there is an even chance that they will be of the same sex. In even more exceptional cases three, four, five, or even six ova may mature simultaneously and be fertilized at approximately the same time. The three, four, five or six resulting children would merely be brothers and sisters of the same age.* These twins developing from different eggs (or, to use the terminology of genetics, different *zygotes*) are called dizygotic or polyzygotic twins. Or to use less erudite language, fraternal twins or pseudo-twins.

2) There is another cause of multiple pregnancies. When an ovum has been normally fertilized, it may separate into two exactly identical ova, which will develop independently of each other. The two ova have the same constitution and particularly the same chromosomal pattern; they will therefore have the same hereditary patrimony. It is not surprising, therefore, that the children born from this divided egg should resemble each other so closely that it is difficult to tell them apart. The division of the ovum may be repeated several times, so that as many as five or rarely six children may develop from the divided egg. The classic example of multiple issue from the same egg is the Dionne quintuplets. Such twins are called monozygotic, identical, or true twins.

If personality is determined by hereditary patrimony more or less moulded by environment, monozygotic twins should be identical at birth. Actually, their environment is not quite the same during gestation, for, aside from the bumps and shocks experienced by one and not the other, the blood circulation of the two fetuses may not be the same, which explains the occasional difference in weight between twins at birth. They are theoretically two identical beings at the start, more or less

* These children born the same day may possibly look more alike than if they had been born at different times. It is possible that chromosomal reduction may be influenced by factors of the moment. Moreover, the children will have shared the same environment during gestation.

slightly differentiated by environment. Needless to say, they are always of the same sex, male or female, depending upon whether the spermatozoon involved carries an x or a y chromosome.

Both of these two causes of twinning may act simultaneously in this way: if the pregnancy involves several eggs, one or more of them may divide. Thus a multiple birth of more than two may result in a mixture of fraternal and identical twins.

Multiple pregnancies may also be complicated by what is known as superfecundation. Two ova, maturing at almost the same time, may be fertilized by two different males. The result would be pseudo-twins who would actually be half-brothers.

Another phenomenon called superfetation is supposed to result from the fecundation of a second ovum during the pregnancy caused by a first. The validity of this alleged condition has been questioned on the grounds that the apparent cases could be explained by the unequal development of two children conceived at the same moment.

The frequency of multiple pregnancies varies from country to country and especially from race to race. Statistically, the phenomenon seems to be rarer in the yellow races. This may be explained by the general narrowness of the pelvis in Asiatics. Or it may simply be untrue, the statistics to the contrary being based on the concealment of multiple births among peoples who regard twins as an evil omen. In any event, statistics do show that among Caucasians double births are eighty-five times less frequent than single births; that triple births are eighty-five times less frequent than twin births; that quadruplets are eighty-five times less frequent than triplets, and so on in the same ratio. This ratio, called Hullin's law, may be expressed as follows, allowing n to stand for the total number of births: $(1/85)^{n-1}$. Thus for a country like the United States, the probability of twin births per year is about forty thousand, that of triplets about four hundred, and of quadruplets only four.

Dizygotic twins are more frequent than monozygotic at the

rate of about three pairs of fraternal twins to one pair of identical twins.

The frequency of double births is a function of the age of the mother. It rises progressively until it reaches its maximum between the ages of thirty-five and forty. At its peak, the frequency is four times what it was at twenty and double what it will be at forty-five. These variations seem to apply only to dizygotic twins. Tendency to bear identical twins is apparently independent of the age of the mother. The age of the father is of no importance, it would seem.

Are double pregnancies hereditary? The answer seems to be yes for dizygotic twins and doubtful for monozygotic. In other words, the property of putting forth several ova simultaneously does seem transmissible, while the fission of the egg is apparently an accident.

It is disturbing to note how much identical twins are sometimes morally dependent upon one another, as though yearning for the unity destroyed by the division of the egg.

II

Single and Double Monstrosities : Teratology : Physical, Chemical and Mechanical Factors : The Thin Line Between Heredity and Environment in the Advent of Monsters : Abnormal Spermatozoa

The dread with which primitive peoples regard twins as evil, sometimes even to the point of sacrificing them, may be based on the realization that twin births are not far from the birth of monstrosities. True twins are, in one sense of the word, "monsters," in that the fission of the egg is not a normal development. However, they are perfect specimens of "monsters" because two complete beings have emerged from the divided egg. When, on the other hand, the fragmentation of the egg takes place after growth has begun, the two embryos may

develop attached to each other, or even with half the body in common. These cases are called double monsters or incomplete twins.

There are also single monsters, developed abnormally from a single ovum. An organ or a limb may be missing, two symmetrical organs may be fused into one, or the development of certain organs may stop abruptly in the course of embryonic life.

When the monstrosity is really serious, the pregnancy ends in miscarriage or the child dies soon after birth. There are, however, viable monsters both single and double. The classic example is of course that of the two Asiatics, Chang and Eng, who were joined together at the lower extremity of the sternum. Since their time, the expression "Siamese twins" has become a synonym for double monstrosities.

To what extent are these occurrences hereditary or fortuitous? This is a question which teratology, a relatively new science, seeks to answer. Teratology—the study of monsters—has been able to produce artificial monstrosities through interfering with the development of the egg by physical, mechanical, or chemical means. These experiments have determined that many diverse causes may disturb fetal development and thus cause abnormal births; shocks of all sorts, mechanical or electrical; physical factors, particularly abnormal radiation, excessive temperatures, and partial asphyxiation; chemical factors such as alcohol, the acids and bases, and poisons of all kinds, especially bacterial toxins.* Better yet, teratology invents new monstrosities. It can, at will, produce four or five embryonic ducklings by cutting up the germ of a duck's egg before incubation. This is an artificial analogy to the mechanics of producing identical twins with this difference: except for birds, not all eggs have the power of complete reconstitution after division.

* It is probable that psychic shock also causes fetal changes. As far as we know, systematic experiments in this complex field have not been carried out.

Most chemical agents provoke characteristic malformations. The sulfa drugs, for instance, and paramino-benzene produce the basset mutation common in dogs. Bacterial toxins set up by the organism itself during illness are common teratogenic substances, which may explain the abnormalities in children born of syphilitic mothers. In any event, measles in a pregnant woman will sometimes cause lesions in the membrane of the eye and in the cardiac system of her unborn child.

Other substances, on the contrary, may act by their absence. A deficiency in vitamin B_2 before gestation will induce malformation of the palate as well as shortening or coalescence of the fingers. Vitamin A deficiency in the mother will affect the eyes of the unborn child (even causing blindness in some cases), as well as harelip.*

The various organs in formation react differently to stimuli at different stages of embryonic development, which explains the irregularity of these mishaps.

How many women ignore the extent of their responsibility? How many do not realize that what they eat, the drugs they take, the bumps they receive and the illnesses they contract may not only hopelessly deform the child they are carrying, but the one they may conceive next year? Women may therefore not claim a man's privilege of living foolishly and poisoning himself as he pleases. Not that a man's behavior does not affect the quality of his spermatozoa; it does; but his direct responsibility ceases at the moment of conception.

It is remarkable that these artificially induced malformations are similar to those appearing in nature, some of which are passed on from generation to generation. Are not the factors which produce these hereditary malformations in nature analogous to the teratogenic agents used in deliberate experiments? When they are known, we may be able to prevent these defects, or at least to keep them from being transmitted.

So the border line between heredity and environment, which seemed so clear-cut in the area of mutations, becomes

* We will have much more to say about vitamin deficiencies in Part Two.

blurred here. On this point at least we find action belonging appropriately to environment disturbing the appearance of phenomena considered unchangeable.

Be that as it may, it is clear that the origin of malformations may be hereditary as well as fortuitous. We must be cautious in blaming monstrosities upon either.

The parallel actions of heredity and environment reappear in the analytical study of the proportion of defective spermatozoa. In their experiments with animals, MacKenzie and Berliner found that the spermatozoa of rams could be 84% abnormal in unfavorable conditions and 15% defective in favorable conditions. Those in the higher percentage were usually unable to fertilize their ewes, and the ewes they did manage to fertilize either dropped their lambs before term or brought forth defective lambs. MacKenzie observed, however, that the proportion of normal births was much higher when the ewes had access to fresh pasturage than when they were fed on silage in sheepfolds. This seems to indicate that the mother's diet may compensate for deficiencies in the father's germ cells. The same studies also reveal the influence of temperature on the proportion of defective spermatozoa. In some animals, the proportion of abnormal sperm rises from 2.5% in January to 22% in August. In other animals, the proportion rises from 18% to 73% in the same seasonal range. It is a remarkable fact that these changes are due not to the seasons but to the temperature, for they can be similarly induced by artificial heating of the premises on which the males are kept.

In the field of humans, Moench and Holt have reached the following conclusions: As a rule, defective spermatozoa constitute less than 20% of an emission. When the proportion reaches 25%, abnormal births begin to occur. At a proportion greater than this we may expect sterility. These figures are questioned by the German researchers Stiasny and Generales. Although they agree that fertility varies in inverse ratio to the proportion of defective spermatozoa, they declare that absolute sterility does not result until the proportion of imperfect sperm

reaches 75%. They do agree that the issue will be abnormal. According to these same biologists, a high proportion of defective germ cells is usual in all hereditary diseases: inherited deafness and blindness, epilepsy, dementia praecox, and chronic alcoholism. While the proportion of imperfect germ cells in normal individuals averages less than 20%, it rises to 62% in mental diseases and congenital deafness, 75% in congenital blindness, 58% in epilepsy, 54% in dementia praecox, and 75% in chronic alcoholism.

These conclusions lead us to ask to what extent these maladies are really hereditary and not due to poisoning of the germ cell by defective environment. Since the spermatozoon may be changed by environmental factors (particularly temperature and alcohol) as well as by heredity, the malformations in the issue may be either congenital or somatic—that is to say, no longer transmissible to posterity once the environment ceases to be unfavorable.

All this shows the complexity of these questions and how the systematic sterilization of defectives, apparently most logical, could lead to scientific error.

Although such sterilization is obligatory or permitted in some parts of Europe and America, we can only approve the great caution, not to say hostility, that it arouses in religious circles. Man's knowledge is still too fragmentary for him to arrogate to himself the power of interfering with the laws of procreation.

III

Comparison of Twins : Differentiation Between the Reactions of Heredity and Environment : Possible Inheritance of Diseases and Defects

The comparative study of twins, identical or fraternal, offers a promising method of settling the question of the relative influences of heredity and environment.

The working hypothesis, we must point out, is based on the following two capital facts:

1) While two children of the same age, strangers to each other, differ considerably even when raised in the same environment,* monozygotic twins living together show a resemblance sometimes amounting to complete identity. Physically, this resemblance is not only apparent but can be confirmed by anthropometry, comparison of blood grouping, and other means.

Their psychic resemblance is also marked. Aside from current observation, it may be confirmed by testing the intelligence quotient, social behavior, tastes, will power, suggestibility, and the tendency to good or evil.

When true twins have lived apart for long years, they still remain very similar, and what differences may be noted in their weight, I.Q., and manners may generally be explained by what we know of diet and education.

It is consequently admitted that if all environmental conditions were identical, monozygotic twins would be identical. In brief, this capital postulate derives from present-day concepts of heredity and the preceding observations on the great resemblance between identical twins leading parallel lives.

When identical twins are subjected to different environments, the only remaining point of identity will be an intangible hereditary character. Their differences will be considered as acquisitions due to environment, in other words, the corresponding hereditary character will be malleable.

2) Dizygotic twins, on the other hand, have different heredities. If they live together, they may be considered as subject to the same environment, including their intra-uterine life. Their points in common may therefore be attributed, in a measure, to their environment—not forgetting that they are nevertheless brothers who may have forty-seven of a possible forty-eight chromosomes in common—or none. Thus they may

* Actually they can have only their postpartum environment in common. Their intra-uterine lives, of such great importance, remain separate.

look almost as much alike as identical twins, or they may be genetic strangers. Under these conditions it is obvious that any resemblance may be due as much to heredity as to an identity of environment.*

Be that as it may, the comparison of pseudo-twins complements that of true twins.

This method allows us to explore the importance of the field in the matter of bacterial diseases. The statistics of Camerer, Weitz, and Schleicher, bearing on a number of subjects, show that measles breaks out simultaneously 98.6% of the time in identical twins, but only 93.5% in the case of dizygotic twins. Mumps appears in both of a pair of identical twins 40% of the time, 25% in pseudo-twins. We may therefore conclude that measles are highly contagious and that the terrain is secondary, whereas in mumps it is much more important.

In the same vein, according to the work of Diehl and Otman Verschuer, if one of a pair of monozygotic twins is stricken with tuberculosis, in 65% of the cases the other twin is similarly infected. In the case of pseudo-twins, simultaneous infection occurs only 25% of the time. This allows us to believe that the hereditary constitution is a very important factor in tuberculosis.

Inversely, investigation by Thums into a possible hereditary factor in multiple sclerosis (caused by sclerotic tissue invading the nerve centers) showed that out of seven pairs of monozygotic twins living in different environments, when one of each pair was stricken with the disease, in only one case did the other twin also contract it. If heredity is a factor here, it is only a minor one. The principal factor is external.

By the same method of studying twins it has been established that in schizophrenia and manic-depressive psychoses, hereditary factors play an important part. Research into the

* For these comparisons, dizygotic twins who are half-brothers arising from superfecundation (either natural or artificial by mixing spermatozoa) would be interesting statistically in having heredities not as closely linked.

heredity of cancer is less conclusive, although hereditary predisposition has not been excluded.

All of which means that hereditary constitution always plays a more or less important part and that environment does the rest. So heredity does not have the fatalistic inevitability attributed to it by the literature of antiquity. Opportune intervention of environment may often prevent misfortune. Besides, the importance of the germ cell, too, has been overemphasized by the early Pasteurians, who were apt to overlook the role of terrain. This is no reproach to the disciples of Pasteur, for scientific "truth" is first of all no more than a working hypothesis, very often as fruitful when it is proved untrue as when it turns out to be "true"—meaning that it may survive a little longer.

The weakness of the study of twins is the difficulty of its application. First of all, identical twins are rare. Second, it is rarely practical to subject them to different environments under scientific control. And finally, experiment with one pair hardly warrants a general conclusion. A large number of subjects is needed in order to produce statistics representative of an average for the race.

We should be able to study experimentally and with rigid controls the action of diet, climate, and education. Meanwhile we must depend on mere approximations obtained by extrapolation from animal experiments to human probability, using inbred specimens (which have closely related patrimonial heredity without being monozygotic twins) obtained by consanguinity over several generations.

IV

Conclusions on Psychic Heredity

Comparison of twins throws considerable light on the question of psychic heredity. Monozygotic twins show much closer intellectual and moral resemblance than do dizygotic twins.

Newman, comparing the intelligence quotients of the two types, found a correlation coefficient of .90 between identical twins against .70 for fraternal twins.* Thérèse Lassen, studying 226 pairs of monyzygotic and dizygotic twins, found the following coefficients for social and moral behavior: †

	Correlation Coefficients	
	TRUE TWINS	PSEUDO-TWINS
Sphere of interests	0.91	0.12
Self-understanding	0.71	0.01
Capacity for effort	0.67	0.35
Attitude toward parents	0.96	0.47
Attitude toward schoolmates	0.86	0.03
Attitude toward teachers	0.84	0.36
Demeanor with plants and animals	0.98	0.44
Will to work	0.86	0.49
Suggestibility	0.92	0.42

Frankly, the correlation between pseudo-twins makes little sense, inasmuch as we do not know the exact degree of their biological kinship. But it is clearly much less than that between true twins, for whom the consonance is highly significant.

In a word, true twins are at birth the same physical and moral individual occupying two bodies, and when they live together, they are differentiated only very slightly by environment.

These studies permit us to conclude in favor of heredity only so far as the psyches of the children may be compared with those of the parents. Marion Outhit found a correlation of from 0.40 to 0.688 between the mental level of the children and those

* The correlation coefficient, or Pearson's coefficient, is the mathematical criterion measuring the degree of similarity between two phenomena. The value 1 represents perfect identity, while the figure 0 represents complete independence.

† According to Maurice Lamy in *Les Jumeaux*. Paris: Corréa, 1949.

of the father or mother, which is not a very high figure. Comparison of the mental level of the children with the average of those of the grandparents, however, gives a much higher correlation: Outhit found 0.80 and P. Cattell 0.84.

These results are still pessimistic, for the determination of a mental level really measures the action of an environment on a psychic patrimony. Now this environment is not necessarily the same from one generation to the next and furthermore the environment has influenced the parents for a longer time than it has the children. So we may be permitted to wonder if the correlation coefficients would not be closer to 1 if the environment had acted equally on descendants and ancestors.*

The variations between children are important. The correlation coefficient between fraternal couples ranges from 0.423 to 0.724, while that between one parent and one child runs from 0.40 to 0.69. So there is slightly more similarity between brother and sister than between one child and one parent.

But—and this is disturbing—Outhit and M. Bures agree that there is little relationship between the different intelligence levels of the parents and the same differences in the children. We may therefore wonder if these differences between children may not be laid to environment—particularly prenatal environment—rather than to heredity.

This hypothesis is apparently confirmed by comparing the I.Q.s of fraternal twins with those of brothers of different ages. Using the Otis test, Herrman and Hogben found a correlation of 0.85 between true twins, 0.50 average between pseudo-twins, and 0.32 between brothers or sisters of different ages. Studies by Newman, Freeman, and Holzinger give similar results: 0.88 for identical twins, 0.63 for fraternal twins, and 0.37 for brothers of different ages. The prenatal environment, of

* The same work of Outhit indicates that the average of the children regresses toward the general average of the population. Here again the explanation seems to lie with environment. Exceptional parents may be in a certain sense the product of an exceptional environment, which may not be available to the children. Hence their regression.

which we shall have much more to say later, thus seems to be a very important cause of differentiation. Everything leads us to believe that the psychic patrimony of each child is further removed from the average of that of his parents than it might seem *a priori*. The differences later acknowledged by the children would seem to be due essentially to environmental influences, especially prenatal.

In conclusion we may thus admit that the genes carry psychic characteristics in the same manner as physical characteristics. Both are hereditary and to the same degree. Perhaps the development of the psychic traits is more susceptible to environmental influence, but this is a phase of the question we shall consider in discussing education.

The manner of transmission of these psychic gifts is another story. However, some of them do seem to be passed on as a group, for apparently different capacities turn up together. Quite probably the generality of psychic qualities derives from a mixed heredity, that is to say the average of both parents. But according to Hurts and Charles Spearman, it would be conditioned by the combination of recessive genes and dominant genes. This highly interesting field is practically virgin to research.

II *Diet and Chemical Environment*

1 ✳ GENERAL CONSIDERATIONS

I

Diversity of Diet among Primitive Men : The Evolution of Nutrition : The Influence of Agriculture and the Growth of Population

We are only beginning to glimpse the importance of diet in the evolution of civilized man.

The food of peoples still in a primitive stage of development —as well as that of the distant ancestors of the civilized peoples of today—is characterized by its great diversity, partly due to a complete lack of prejudice. The primitive eats practically anything that lives, from the large herbivorous animals down to the insects and grubs which he makes into pap. His eclectic tastes extend to the creatures of the sea and also to all parts of the beast he considers edible. While the civilized palate seems to prefer muscle tissue, the primitive eats everything, especially the internal organs.

All primitives eat vegetable as well as animal matter. And where plant life is scarce, as in the Arctic, the Eskimo will hunt his vegetable diet in the very stomach of the reindeer he has killed.

Primitive man does less cooking than his civilized brother. He eats many fruits and vegetables raw, as he does eggs and milk.

Most primitive peoples live essentially by hunting and fishing. Agriculture appears only when an increase in population requires a greater yield from the earth. Diet then begins to change through the selection of cultivated plants and the introduction of new vegetable products from other regions. Finally agriculture is oriented more and more toward such high-yield crops as wheat and potatoes, and the primitive diversity gives way to a wide degree of uniformity. Concomitantly, more and more meat begins to come from domesticated animals having a different feed from wild game and an inferior quality of flesh. The gap between natural and civilized diet grows with the increase in density of population.

Mineral fertilizers change the composition of vegetation. Artificial preservation of foods, by destroying or abating bacteria, cause more or less profound changes in the composition of a diet.

Under influences not yet well understood, tastes change gradually, inclining toward refined products further and further removed from their natural state, such as white flour and sugar. So there remains nothing in common between the varied diet of primitive man, based on wild plants and animals eaten fresh in their natural state and in their entirety, and the diet of the contemporary city dweller, living on white bread made from bleached flower milled from high-yield wheat, on the muscles of domesticated animals also artificially fed, and on various foods preserved for years by sterilization with superheated steam.

If these modern foodstuffs sometimes retain something of their natural taste, they are nonetheless profoundly different basically and their consumption creates new chemical conditions in the development of the human organism.

Among all the many changes brought about by civilization, none is more profound or of greater moment than that in the diet of man. And yet most men regard the process of eating as

important only in the satisfaction of their hunger or their gluttony.

II

Rudiments of the Science of Nutrition : Equivalents in Energy : Caloric and Protective Principles : Animal Proteins : Plastic and Catalytic Mineral Principles : Vitamins

The scientific study of nutrition is necessarily conditioned by the progress of chemistry. Its point of departure was twofold: 1) The discovery that nitrogen in living tissues came not from the air but from nitrogenous food; 2) The discovery of the importance of carbohydrates, particularly sugar, in the work of the muscles.

At the end of the eighteenth century, physiologists were beginning to experiment with the interchange of different foods. The first hypothesis, Max Rübner's, was based on energic equivalents. Auguste Chauveau's theory, which was more accurate, involved glycosic equivalents. Finally Pierre Berthelot established the gross energy value of each of the calorigenic principles. Taking into account the fact that combustion *in vivo* is naturally incomplete, particularly of proteins, energy equivalents may be calculated on the following basis, known as the Atwater coefficients:

Proteins or proteids* .... 4 calories per gram.
Fats or lipids* .... 9 calories per gram.
Carbohydrates or glucosides* .... 4 calories per gram.

All these equivalents in thermic terms concern only the energic functioning of the body and consider neither its formation

* Food sources of these energy factors will be found in Chapter IV.

nor upkeep. Yet experiments show that young animals nourished only on caloric factors—that is to say, elements which produce energy only by oxidation in the organism—do not grow normally. On the same diet, adult animals all waste away. One may as well ask an engineer to build and maintain an automobile with gasoline only.

There are other nutritional factors, designated as protective or constructive, which are essential to normal growth. They are principally the amino-acids and the elements of inorganic chemistry. They are all present in various proportions in calorific foods in their natural state. Proteins, for instance, contain protective amino-acids, while sugar is a pure caloric factor. So a minimum of protein is necessary for development, a smaller minimum for animal protein than for vegetable. The amount of nitrogen being equal, best results are obtained from a mixture of both proteins in roughly equal parts. An adult man, normally active, requires a minimum of about 100 grams a day of protein.

The mineral elements necessary to the building of the body are either plastic—that is, capable of undergoing metabolic change—or catalytic—meaning that they induce changes in other elements without themselves undergoing change. In the first category are calcium, sulphur, phosphorus, chlorine, and potassium—in a word, the materials of construction, and the regulators of the alkalinity of the body fluids. In the second we find iron, zinc, copper, manganese, iodine, and fluorine—all indispensable in the formation of such life substances as hemoglobin and thyroxine.

Two other essentials in nutrition are water and cellulose, necessary for solution and dilution. Although both are eliminated almost unchanged, they are needed in the assimilation of food and the functioning of the body.

All early experiments in feeding animals with synthetic products which contained all the above factors failed. Something was still missing. This failure led to the discovery of vitamins.

2 * THE LAWS OF NUTRITION

I

The So-called Deficiency Diseases : Scurvy and Vitamin C : Beriberi and Vitamin B : Pellagra and Vitamin PP : Day Blindness, Xerophthalmia and Vitamin A : Rickets and Vitamin D : Sterility and Vitamin E : Bleeding and Vitamin K : Vitamin H and the P Factor

Among the maladies which afflict mankind are those called "nutritional diseases" which can be prevented and cured by the simple absorption of enough fresh, natural food products. This fact has been proved. We can still wonder, however, what other diseases, even those produced by bacteria, might not be cured or avoided by proper diet.

The history of the study and treatment of these diseases of nutrition is in a measure the story of the science of nutrition. Hippocrates already described the symptoms of a fatal disease rampant in the ancient Greek armies: red and livid spots on the body, leaden complexion, increasing hemorrhages, receding gums and falling teeth. The chronicles of Jean Joinville relate the sufferings of the Crusaders from "rotting flesh." All

the great maritime explorers, particularly Vasco da Gama and Jacques Cartier, suffered heavily from this disease called scurvy, which seemed to single out sailors, explorers, troops in the field and the citizens of besieged cities.

At the end of the eighteenth century Captain James Cook spared his crew from the disease by making them eat oranges and lemons. A century later the surgeon-general of the French navy, LeRoy de Méricourt, praised this therapy before a skeptical Academy of Medicine.

Norwegian doctors noted that guinea pigs contracted scurvy when deprived of fresh vegetables but that rats and pigeons developed normally under the same conditions. Autopsy of the guinea pigs revealed massive internal hemorrhages, particularly in the hind legs. The juice of citrus fruits prevented or cured this condition. It was therefore concluded that the juice of fresh fruits and vegetables contained a water-soluble antiscorbutic agent, which was later called Vitamin C. It is worthy of note that some animal species, such as the rat and the pigeon, are immune to scurvy.

The end of the nineteenth century saw the appearance of an infantile scurvy, called Barlow's disease, which attacked babies who were not breast-fed but who were given sterilized or boiled milk. Addition of fruit juices to the baby's formula prevented the disease.

While scurvy was a world-wide disease, the peoples of Africa and especially Asia were afflicted with a malady called beriberi. Paraplegic or "dry" beriberi attacks the legs and the nervous system. Cardiac or "wet" beriberi attacks the heart and lungs. Death is caused by heart failure or edema of the lungs.

Toward the end of the nineteenth century, Japanese doctors noted that their sailors died of beriberi while European sailors were immune. Substitution of meat and vegetables for part of the normal Japanese diet of polished rice caused the disease to disappear. Subsequent studies showed that peoples who ate unpolished rice rarely had beriberi. A Dutch doctor, Christiaan Eijkman, finally demonstrated that chickens fed on pol-

ished rice developed the nervous and paralytic symptoms of beriberi while those eating whole rice remained immune. After trying to isolate the toxic substances he believed were contained in the polished rice, he decided that on the contrary, it was the removal of life-preserving elements in the husk and outer layers of natural rice which caused the disease.

In 1912-13, E. V. MacCollum, Thomas Osborne, Davis and L. B. Mendel put young rats on a diet of purified casein, dextrin, and lactose, combined with mineral and other non-nutritious matter. They noted that the less the lactose was purified, the better the animals developed. In fact, when it was 100% pure, the rats developed characteristic nervous symptoms analagous to those of Eijkman's chickens, always followed by death within a month. The addition of butter to the diet did no good. However, brewers' yeast, rice bran and wheat germ proved specific remedies—so the experimenters decided that the three materials contained a water-soluble factor necessary to the maintenance of life.

At about the same time Dutch scientists reproduced similar nervous symptoms by feeding their experimental animals food which had been sterilized at high temperatures. Casimir Funk was the first to try to identify the unknown factor which could be destroyed by heat. He concluded that it was a nitrogenous organic substance—an amin—which, since life depended upon it, he called a vitamin. The word has come into universal use to designate any similarly essential factor, even those which do not contain nitrogen.

The anti-beriberi vitamin was called B. We have subsequently learned that it is a complex vitamin, composed essentially of an antineuritic factor designated B_1 and a factor necessary to metabolism called B_2. The absence of B_2 causes emaciation and stops growth. The component parts of B-complex have increased until they now number around a dozen, some of them active only in certain animal species.

Although Europe has never had to face the beriberi problem, it has a similar deficiency disease in pellagra, characterized by dermatitis of all skin exposed to the air—hands, face,

legs and neck. The skin swells, principally in spring, and digestive troubles develop, accompanied by dizziness. Mental disorders follow, then insanity and death, often by suicide.

The peoples afflicted by pellagra in Italy, Southern France and Romania all had one thing in common: their principal article of diet was corn. In the southern United States corn-eating Negroes are much more susceptible to the disease than whites who can afford to eat meat and drink milk.

Joseph Goldberger succeeded in proving that the disease, originally believed to be of infectious origin, was due exclusively to dietary causes. Noting the similarity between pellagra and other B-vitamin deficiency diseases, Goldberger and his colleagues discovered a special vitamin which they called PP (pellagra preventative), which is actually one of the factors of B-complex.

One of the oldest diseases known to mankind is hemeralopia, or day-blindness. The ancient Egyptians treated it by feeding the patients raw liver. It is apt to degenerate into xerophthalmia, with eye lesions, thickening of the conjunctiva, and even total blindness, particularly in regions without milk or butter—such as Indonesia—where it attacks children.

About the middle of the nineteenth century some authorities began to suspect the dietary origin of this disease, but it was MacCollum, Osborne, Davis and Mendel who first determined the cause during the course of their experiments described previously. Their experimental animals fed on the casein-dextrin-lactose diet developed xerophthalmia symptoms—until butter and egg yolks were added to their food. Since the vital factor they discovered was obviously alimentary, they called it Vitamin A.

A disease of growth which affects the children of many countries is rickets, which distorts the growth of the skeleton, softens the bones, causes deviation of the spine, malformation of the skull, and general debility. The earliest known remedy for rickets was exposure to sunlight, a questionable therapy since African and Indian peoples, who get plenty of sun, are far from immune to rickets, while most northern peoples can

boast sturdy bones from birth. The northern peoples turned out to be great fish eaters and it became evident that fish-liver oil was good for rickets, long before the active agent in the oil was discovered. It was not until 1917 that experiments, based on those which revealed the cause of beriberi and scurvy, also put the finger on the cause of rickets.

Dogs subjected to a deficiency diet which produced rickets were cured by cod-liver oil, while other fats such as butter were less efficacious. It was still supposed that Vitamin A was the remedial factor—until it was further shown that the calcium-phosphorus imbalance which caused the bone damage in rickets was unaffected by the presence of Vitamin A. It was finally determined that the missing factor was an oil-soluble agent that was named Vitamin D—more stable and less easily oxidized than Vitamin A.

These nutritional maladies affect the soma—the sum of all body cells with the exception of the germ cell. And yet it had long been suspected that the germ cell, too, was affected by diet, although no one had ever been able to determine the exact cause for deficiencies in reproduction. About 1925, however, experiments demonstrated that rats deprived of wheat germ, while apparently normal in all external signs of their sex, became practically sterile. This new anti-sterility factor in wheat germ was called Vitamin E. It is oil-soluble.

In a similar manner the Danes in the early 1930s discovered that subcutaneous and intramuscular hemorrhages in young animals subjected to a scurvy-producing diet did not disappear even after the injection of citrus juices. Further experiment revealed that the missing factor, the antihemorrhagic agent, the element in the diet that induced blood clotting, was a fat-soluble substance which the discoverers called Vitamin K.

And so the list of vitamins grows longer.

Without mentioning the elements of B complex (B_1 the antineuritic; B_2 the nutrition-controlling lactoflavin; pantothenic acid; biotin or Vitamin H; para-amino benzoic acid or Vitamin H′; folic acid; and so on), new research has demonstrated

the existence of an essential element in fats, plus fat-soluble vitamins A, D, E, and K—linoleic acid, also called Vitamin F. Furthermore, the resistance of the capillaries now seems conditioned by a P factor, active only in the presence of Vitamin C, sometimes called Vitamin P.

The ABC of vitamins is in danger of running out of letters, for there is no doubt that research in this field has scarcely begun. If the nutritional bankruptcy which causes the classic deficiency diseases has been discovered, there is great probability that more vitamins will turn up which not only govern resistance to other maladies but also condition all cellular and humoral life, perhaps even moral and intellectual life.

We are only beginning to be aware of the importance of nutrition in the growth, behavior and pathology of men. For ages cattle breeders have known that animals cannot be fed just any-which-way. But it has been considered sacrilegious to think that a demigod could be subject to such sordid exigencies. The most that could be admitted was that the human machine might need a minimum of fuel from time to time. But alas, even thought itself depends upon nutrition, a fact which is neither humiliating nor materialistic.

II

How Vitamins Act : The Danger of Artificial Overdosage : Thermostability and Oxidation : Alteration of Vitamins by Food Processing

As vitamins are active in very small quantities, their action is often described as catalytic. In the strictest sense, this term may lead to error, as some vitamins enter into direct action in the assimilation of food or the neutralization of toxins, and are themselves eliminated in the process. For instance, vitamins of the B-group participate in the formation of diastases without which the assimilation of some foods would be incomplete and the residual products would poison the system. So

actually these vitamins are consumed, something which never happens to a catalytic agent. A catalyst acts by its mere presence and remains unchanged.

In a general way we know that Vitamin A conditions growth. Is it by acting as a brake on the thyroid gland, which regulates the combustion of body fuels? It also acts as a sort of natural antiseptic, counteracting the invasion and proliferation of bacteria in the mucous membranes. Its deficiency is noted primarily by the appearance of eye infections, but predisposition to the infection of other mucous surfaces in the respiratory and genital tracts may perhaps also be attributed to lack of A.

Deficiency of Vitamin B_1 stops the assimilation of sugars and the toxic residual products cause changes in the nerve centers. The loss of appetite characteristic of this deficiency may be due to the accumulation in the blood stream of sugars and starches insufficiently broken down. Lactoflavin or B_2 also influences growth by controlling absorption of food by the intestines. Absence of the PP factor induces skin trouble and nervous instability of which pellagra, ending in insanity, is the ultimate stage.

Vitamin C deficiency first causes a tendency to small hemorrhages due to weakening of the capillary walls. It also influences the workings of the ductless glands. The fact that animals deprived of Vitamin C are prone to general infection allows us to suppose the vitamin is also a germicidal agent. And finally it may neutralize the toxic action of substances normally produced by the body, which is not properly speaking a catalytic action and which explains the relatively large amount of Vitamin C needed to maintain health.

Vitamin D affects particularly the development of the skeletal system. By its role as a fixative of calcium phosphate in the bones, it remedies imperfect liaison between calcium and phosphorous. Its deficiency is an important cause of tooth decay.

Vitamin E regulates sexual development, particularly fertility. It is a vitamin which determines the differentiation in bees. The queen bee's diet is rich with Vitamin E, while the workers'

food has none. Recent discoveries indicate this vitamin has an influence on the pituitary and thyroid glands.

Complete deficiency of Vitamin K has been found only in birds, for it is normally elaborated continuously in the human intestine. Vitamin K regulates the clotting of the blood. Its partial deficiency in man is due to pathological conditions of the intestines or the hepatic system.

Vitamin deficiency is not the only cause of man's troubles. An excess is equally dangerous, especially of fat-soluble vitamins.

An excess of Vitamin A affects the liver, it is believed. And it is certain that an overdose of Vitamin D during pregnancy will induce disordered calcification in the embryo. The arteries lose their flexibility and lime deposits are scattered throughout the body, particularly in the kidneys. In extreme cases the arteries of the embryo may become completely calcified.

The quantity of each vitamin required by the body obviously depends on the amount and nature of the food absorbed. Vitamin B requirements, for instance, depend upon the quantity of sugars and starches in the diet.

Some vitamins complement the work of each other, others are inimical. Vitamin D opposes the actions of similarly fat-soluble Vitamins A and E. On the other hand, Vitamins A and D reinforce the action of Vitamin B. This complexity of actions demonstrates the danger of a haphazard self-dosage of artificial vitamins. In natural foods, vitamins exist always in proper proportions.

The properties which determine the keeping qualities of vitamins in foodstuffs are their oxidation and their resistance to heat. Vitamin C is very sensitive to heat, for instance. Cooking causes the almost complete destruction of this vitamin in milk and green vegetables. And yet, exceptionally, cooking increases the concentration of C in potatoes. Vitamins A and B_1 are little affected by cooking, while D, E, and B_2 are scarcely touched at all.

Destruction of vitamins is due to their oxidation, which de-

pends not only on heat but on the presence of oxygen and the acid-alkaline balance of the medium. For instance, Vitamin C is much less susceptible to oxidation in an acid medium than in alkali. In the absence of air, Vitamin C may be heated to a very high temperature without change.

The changes in the vitamin content of preserved food are caused by this sensitivity to heat. Sterilization at temperatures above 212° F. destroys Vitamin C and partially destroys A and B_1. Artificial drying by heat affects the same vitamins in the same ratio. Smoke curing has the same effect. Cold, on the other hand, while slowing chemical and biological reactions, causes little change in vitamins. Foodstuffs do not lose their vitamins by merely being kept in stock, except that some oxidation will take place in the long run.

In a word, fresh foods are richer in vitamins than cooked, canned or cured foods, particularly in Vitamin C.

So man, ingenious animal that he is, after first deteriorating his foodstuffs through agriculture and intensive production, then damaging them further by cooking and sterilization for canning, tries to make amends by manufacturing synthetic vitamins. But, since he knows so little about the character and actions of vitamins, he administers them at random—and his children may thus be born with arteries as sclerotic as old men.

Certain pessimists believe that we might be wiser to try a reconciliation with nature. What evil tongues to speak ill of science!

III

The Basic Laws of Nutrition : Requirements in Energy and Protective Factors : Animal Protein, Calcium, Phosphorus, Iron, Iodine, the Vitamins : The Necessary Balance

The basic laws of nutrition as acknowledged and taught today may be summed up as follows:

1) *The Energic (or Caloric) Law.*

This, the oldest and widest-known of the laws of nutrition, determines the necessity of furnishing the human machine with the number of calories required according to age, physiological condition, and activity.

The food sources of energy in this area are divided into three general categories: proteids, fats, and glucosides, the values of which have been discussed in Chapter One, Part II.

The proteids, also called nitrogenous or albumoidal products, are in decreasing amounts in the following staples: process cheese and dried vegetables, meat, fish, oleaginous seeds, eggs, cereals, fresh cheese, bread, milk, fresh fruits and vegetables, butter.

The fats (or lipoids) are chiefly found in oils, animal fats, butter, oil seeds, cheeses, fat meats and fish, eggs and milk.

The glucosides have in general a chemical formula comprising in varying proportions carbon and water and are consequently also called carbohydrates. They enter generously into the composition of sugars and cereals, dried fruits and vegetables, almonds, walnuts and hazelnuts. They are found in lesser proportions in fresh fruits and vegetables, and in small amounts in milk and cheese. Generally inexpensive per calorie, they represent the chief source of energy for the great majority of people.

Finally, there are some products like vinegar and alcohol which do not fit into any of the three categories, but since the proportion in which they are burned by the body is not well understood, they are of lesser interest as sources of energy.

The caloric requirements of the body must necessarily match the energy expenditure, with the reservation that the body can store energy and the output is never exactly equal to the intake. However, comparison with an inanimate machine has its limits, since even in total repose the energy expenditure of the body cannot fall below a minimum corresponding to the basal metabolism—about 1,500 calories a day for the average adult male. During actual work the requirements may rise

to 500 calories an hour, so that an active worker will need from 2,500 to 4,500 calories a day to compensate for muscular energy expended.

A pregnant woman or a nursing mother requires 2,500 to 3,000 calories a day. The requirements of children vary from 1,000 calories a day in their third year to between 2,500 and 3,200 calories in their eighteenth, depending upon physical activity.

2) *The Law of Body Building and Maintenance.*

A proper diet obviously must contain sufficient constructive and maintenance factors. Protein requirements needed to furnish essential amino acids has been fixed at 100 grams a day —which will usually also furnish the necessary one gram of sulphur.

For an adult, the calcium needed is about .70 grams a day, along with 1.30 grams of phosphorus. The body retains scarcely half of these minerals taken in assimilable form. Minerals absorbed in the form of animal matter are more useful than those obtained from vegetables, because digestion of the first is aided by the presence of fat-soluble vitamins.

Other plastic and catalytic minerals exist in the blood and body fluids, each with a specific role, and their replenishment is essential. The body needs 10 milligrams of iron a day, much of which can be obtained in an assimilable form from cereals. Vegetables, meat and eggs also contain iron. Milk has practically none. The suckling infant hence must live on his fetal iron reserves, which means that a strictly milk diet should not be continued after the tenth month—about the time the first teeth appear, which thus seem well timed and not by pure chance. Spinach is rich in iron but generally in a form not easily assimilable by children under ten.

The daily ration of iodine is about .014 milligrams, but its content in most foodstuffs is not completely known. The absence of iodine from the water and food products of a region engenders a high frequency of thyroid trouble, particularly goiter, which thus becomes a nutritional disease.

Finally, vitamins represent an important proportion of protective factors. The requirements depend upon physiological conditions and on activity. The more active a man is, the more he needs of the B-group vitamins which control his utility of food. On the other hand, the A, C and D requirements seem to be independent of the degree of a man's physical activity.

The requirements are summarized in Table I. Amounts given are for optimum needs. The daily minimum is about two-thirds of the optimum dose.

It is obviously difficult to indicate the quantities of natural foods needed to supply the indicated vitamin requirement, partly because vitamin measurements are not made with any great precision and partly because the content of the protective factors in foods may vary with climate and soil conditions. However, we can give an approximation of the quantities which will furnish the daily needs of a sedentary adult, if only to show how many people are not getting enough vitamins, and to get them to examine their vitaminic consciences.

Vitamin A: 20 to 30 drops of fish oil, 120 grams of butter, 25 grams pork liver, 20 grams of green cabbage, 30 grams of carrots, 50 grams of parsley, 40 grams of water cress.

Vitamin B_1: 20 grams of brewers' yeast, 300 grams of pork liver, 400 grams of cereal grain or of soy beans.

Vitamin B_2: 50 grams of brewers' yeast, 75 grams pork liver, 100 grams calf's liver, 250 grams of oily fish, 1,500 grams of fresh milk.

Vitamin PP: 30 grams of brewers' yeast, 100 grams of calf's liver, 1,000 grams of fresh spinach.

Vitamin C: 75 grams of parsley, 200 grams of spinach, 100 grams of green cabbage, 150 grams of water cress, 250 grams of ripe tomatoes, 150 grams of oranges or lemons.

Vitamin D: a few drops of cod- or halibut-liver oil, 200 grams of summer butter, 100 grams of mushrooms.

Table I

OPTIMUM DAILY VITAMIN REQUIREMENTS*

	A USP units †	B_1 mgrs.¶	B_2 mgrs.	PP mgrs.	C mgrs.	D USP units
MEN (ABOUT 150 LBS.)						
Very active	5,000	2.3	3.3	23	75	400-600
Sedentary	5,000	1.5	2.2	15	75	"
WOMEN						
Very active	5,000	1.8	2.7	18	70	"
Sedentary	5,000	1.2	1.8	12	70	"
Pregnant (last 5 months)	6,000	1.8	2.5	18	100	400-800
During lactation	8,000	2.3	3.0	23	150	"
CHILDREN UNDER 12						
Under 1 year	1,500	0.4	0.6	4	30	"
1 to 3 years	2,000	0.6	0.9	6	35	"
4 to 6	2,500	0.8	1.2	8	50	"
7 to 9	3,500	1.0	1.5	10	60	"
10 to 12	4,500	1.2	1.8	12	75	"
CHILDREN OVER 12						
Girls, 13-15	5,000	1.4	2.0	14	80	"
Girls, 16-20	5,000	1.2	1.8	12	80	"
Boys, 13-15	5,000	1.6	2.4	16	90	"
Boys, 16-20	6,000	2.0	3.0	20	100	"

* According to the National Research Council, 1945.
† A USP unit is a prescribed amount as standardized by the United States Pharmacopoeia.
¶ A milligram is .001 of a gram, or about .000035 of an ounce.

3) *Law of Balance between the Nutritional Principles.* Normal functioning of the human organism requires chemical balances, controlled by different regulatory systems. Some physiologists believe that the diet should show a balance between nutritional principles in order not to overburden the controls.

The desired equality between animal and vegetable proteins has already been noted. The same equality between animal and vegetable fats is also desirable. As nonmetallic elements acidify the body fluids and metallic elements alkalinize them, a diet which balances the two in order to achieve chemical neutralization would be desirable.

And let us not forget the essential balance between calcium and potassium—between .6 and .7 grams a day of calcium to every 1.2 or 1.3 grams of potassium. For growing children and pregnant women the calcium needs are double.

IV

Practical Conclusions on the Make-up of Food Rations : Relative Costs of Energic and Protective Foods

In establishing a suitable food ration we must not lean upon the energic theories which take no cognizance of the physiology of nutrition. The more-or-less recent nature cults are no less dangerous. Vegetarianism, which bans the flesh of dead animals but accepts eggs and milk products, seems to court the upsets of malnutrition, especially in the more delicate periods of childhood and gestation. Fruitarianism and strict vegetarianism (which does not even permit the eating of dairy products) are still more dangerous.

The daily ration of an adult man of average activity should contain both energic and protective principles as follows:

1) Animal protein to the extent of 25 to 35 grams, which represents four eggs, or 150 grams of cheese or red meat, or 200 grams of fresh fish.

2) Fats, in addition to that contained in the preceding, to the extent of another 25 to 30 grams, which would be found in 30 grams of oil, or 40 grams of butter or animal fat.

3) Protective elements not contained in the preceding, particularly foods containing Vitamins A and C, mineral salts and cellulose, say 150 grams of raw vegetables or four times that amount of cooked vegetables, to which should be added 150 grams of fresh fruit.

4) The first three categories represent chiefly protective factors and represent only about 800 calories. The 1,500-1,600 calories needed for a man of average activity may be completed by carbohydrates: bread, sugar, or potatoes, which are the least expensive caloric sources.

For heavy manual laborers who may expend up to 4,500 calories a day, it is not necessary to triple the protective factors except for vitamins of the B-group which regulate metabolism. The extra energy may be furnished by carbohydrates. Thus a manual laborer may seek a greater percentage of his energy in the sugar bowl than the white-collar worker.

During periods of growth, pregnancy or lactation, protective factors found in proteins, vitamins and calcium should be augmented up to 50%.

A study of comparative prices of energy foods in different countries shows that foodstuffs rich in the protective factors are much higher priced than strictly energy foods, caloric content being equal. A survey by the League of Nations just before the start of World War II shows the following price proportion, using "1" as the unit of cost of a single calorie of rice or wheat:

	U.S.A.	*Germany*	*Belgium*
Wheat or rice....	1	1	1
Bacon	1.24	1.65	—
Sugar	1.43	1.35	—
Milk	8	3	4.5 (skimmed)
Meat	11	10	11
Eggs	15	9	16
Fresh vegetables..	17 (cabbage)	10 (cabbage)	16

This explains why, in all countries, the poor may eat their fill only if they sacrifice the most costly foods containing the protective factors in favor of the cheaper carbohydrates. The less privileged, especially those of the cities, are the worst nourished—even when they are not hungry. It may even be possible that their alimentary deficiencies may be among the causes of their social stagnation.

V

Notes on the Problem of Alcohol

Whether the consumption of alcohol is useful or harmful has long been the subject of many controversies. The combustion of alcohol in the system produces heat to approximately 7 calories per gram, which is somewhere between the 4 calories per gram produced by glucosides and the 9 calories generated by fats and oils. The combustion of alcohol is characteristically slow. According to Emile Terroine, 30 grams of alcohol—about the alcoholic content of a pint of wine—require seven hours to be completely oxidized. According to Nicloux, four times that period is necessary.

Some manual laborers believe that alcohol is a source of energy essential to any considerable muscular work. Recent physiological research which seems to contradict this belief indicates that the energy from alcohol cannot do the muscular work of energy from glucosides and fats. Other physiologists declare that alcohol produces body heat which is a defense against the cold.

In any event, the capacity of the body to burn alcohol is strictly limited, currently estimated to be about 30 grams a day for a sedentary person and 60 grams (the equivalent of about a quart of wine) for a manual laborer. Some authors regard these figures as somewhat pessimistic. The divergence is

typical of physiological questions studied on an insufficient number of cases.

In any case, the quantity of alcohol beyond the amount that can be normally eliminated accumulates to produce the characteristic traumata of alcoholism: cirrhosis, neuritis, mental disturbance, premature senility, deficient heredity. Alcohol also inhibits the action of vitamins. For instance, the liver, in the presence of alcohol, finds difficulty in the synthesis of Vitamin A, from carotene on. Excess alcohol slows the absorption and reaction of Vitamine B_1, which explains the nervous symptoms characteristic of acute alcoholism. Some French and American authorities even suspect that alcoholic polyneuritis may be nothing more than a form of avitaminosis. If true, we may some day expect to see alcoholic polyneuritis prevented by administration of Vitamin B_1 in sufficient quantities.

The picture is less clear in the case of Vitamins B_2, C and K, although the frequency of grave hemorrhages in alcoholics seems to indicate a difficulty in the utilization of the antiscorbutic vitamins. And pellagra is both frequent and serious in alcoholism.

Alcohol may also prove toxic to the germ cells. While it is not sure that it attacks the chromosomes, at least it seems to poison the germ plasm and induce troubles in the hereditary processes, so typical in the descendants of alcoholics.

Like all poisons, alcohol in small doses may be a stimulant. In any case, if it has caloric value, it cannot be described as primarily protective. Its use involves the same consequences as the abuse of sugar and white flour. Covering a too large portion of metabolism and by this fact reducing hunger, alcohol hinders the digestion of foodstuffs rich in constructive and protective principles.

3 ✳ DIVERS RECENT OBSERVATIONS

I

Vitamin Synthesis in Animals : Reproduction among Wild Animals in Captivity : Influence of a Mother's Diet on Pregnancy and Birth : The Pituitary and Vitamin E : Influence of the Germ Plasm on the Nutritional Environment of the Fetus

All rules remain abstract unless illustrated by observed examples from life. This observation *in vivo* is complicated by the fact that some animals have the power of synthesizing certain classic vitamins. Thus experiments in Vitamin C deficiency cannot be performed with rats, which are immune to scurvy. Similarly, guinea pigs are immune to rickets because they produce large quantities of Vitamin D in their bodies. Dogs are doubly fortunate because they synthesize both Vitamins C and D. On the other hand, birds lapse rapidly into nervous disorders when deprived of Vitamin B_1.

Perhaps there are vitamins special to these animals which the

human body ignores because it produces them naturally. The question if answered may some day shed light on the evolution of living creatures.

Wild animals living in complete liberty never suffer the deficiencies developed by domesticated animals. Tame animals, spoiled by their masters, are particularly prone to show signs of deterioration. Weston Price, in *Nutrition and Physical Degeneration,* reports that a monkey fed chiefly on sweets by its mistress had such a bad case of rickets that the tension of its muscles deformed the bones of its limbs. The same author cites the example of four cows fed for two years on grain and hay harvested long before. Of the six calves dropped during the period of experimentation, two were stillborn, one was never able to stand and died quickly, and the three others were blind and feeble.

One striking observation was that of the reproduction of felines in captivity. It had long been noted that only females born in the jungle were fertile when caged. The sterility of wild animals born in captivity has caused many expensive replacements in zoos, so the London zoo sent a specialist to the jungle to observe the problems of life and reproduction of the big felines. He noted that when the big cats had killed another animal, they feasted on its organs, particularly the liver, and that they often disdained muscle tissue completely. Until this time wild animals in zoos had been fed almost exclusively on muscle tissue. The addition of internal organs from the slaughterhouse did wonders for the fertility of lions in captivity—and lion prices dropped sharply.

This taste for organs is not peculiar to the big cats. Rats who raid a rabbit hutch frequently eat only the eyes and the brains of the rabbits. Ferrets and weasels suck only the blood of their victims. As a rule the smaller meat-eaters first feast off the organs of their prey.

Vitamin E, vital to conception, also governs postnatal growth by its influence on the pituitary. Young rats experimentally subjected to a deficiency of Vitamin E by Barrie

showed the same symptoms as those whose pituitary had been removed.

Price records his observations on human specimens—two sisters born of the same parents. For her first accouchement, the mother, who had been badly nourished all her life, was in labor for thirty-three hours. The child was born with underdeveloped jaws and a defective nervous system. The mother was an invalid for several months. During her second pregnancy the mother was fed a rational diet based on the protective principles: milk, green vegetables, seafood, animal organs, cod-liver oil and vitamin-rich butter. The second accouchement took only three hours and the second daughter was not only a fine-looking child but developed with perfect mental and physical equilibrium.

Price also described cures effected on children who were in a desperate condition because of malnutrition. He had been called to the bedside of a little boy of four and a half who was dying in convulsions. The convulsions were so violent that the child had broken his femur and the fracture refused to heal. The lad had been living on white bread and skimmed milk. The defective diet was changed immediately to whole-wheat bread made from freshly harvested grain, whole milk, and vitamin-rich butter. The convulsions stopped almost at once, the broken femur healed quickly, and in a few weeks the boy was back on his feet.

In another case a child of five was confined to a hospital bed with arthritis and grave cardiac symptoms. The child's diet had been based on white bread, which was changed to whole-wheat. He was given whole milk, butter made from the milk of cows grazing in green wheat fields, and cod-liver oil. The child's pains quickly disappeared, his appetite returned, and after a year he had developed into a fine-looking, healthy boy.

To avoid all misunderstanding, I must again emphasize that these nutritional influences are purely somatic, as may be seen

from the following experiment: A litter of piglets, born blind because of Vitamin A deficiency in their parents, were correctly nourished on a diet rich in Vitamin A. When they were crossbred, they produced perfectly normal offspring. Breeding one of the blind piglets with its mother also produced normal issue, thus proving that the germ plasm had remained intact.

The independence of the germ plasm from its environment has given rise to the belief that the way of life of the father has no effect on the deficiency of the issue. All responsibility for the child's prenatal life would be thus incumbent upon the mother. In a word, the father's part would extend no further than furnishing the child with genes, which would be environment-proof. Only the mother would transmit the influence of environment.

I hasten to add that this theory has been invalidated by various experiments which have also led us to believe that nonhereditary physical defects—that is to say, somatic—may indeed be transmitted by the spermatozoon. On this subject Price cites the case of four bitches sired by the same incorrectly nourished dog. All the puppies had split palates and spinal deformities, which Price attributes to the poisoning of the generative cells of the male. All hereditary explanation was excluded, since the sire was otherwise normal. It would have been interesting to complete the experiment by proving that in other environmental conditions, particularly that of nourishment, the dog could sire normal issue.

In the human field, Price describes the case of an Eskimo woman who retained her tribal dietary habits even after marrying a white man who remained faithful to the food of his civilization. Despite thirty-six conceptions, the Eskimo woman remained in perfect health without even one decayed tooth. All her accouchements were easy. The man, on the other hand, developed a deformation of the jaw and the face as well as a generalized state of tooth decay. Several of the children were abnormal. One girl in particular showed masculine morphology with characteristic incomplete development of the

pelvis. This girl married, went through a painful and difficult delivery because of her own birthright, and gave up all thought of further childbearing. Price attributes her malformation to poisoning of the father's germ plasm. This conclusion is permissible only if we can exclude some possible unrevealed hereditary factor in the father.

The above observations are akin to the studies by MacKenzie and Berliner and by Moench and Holt in Part I, Chapter V.

Spermatozoa may become defective as the result of high temperatures or chronic alcoholism. There is no doubt that malnutrition may produce the same effect. It also appears from the above studies that nourishment of the mother during gestation with foods rich in protective factors may to some extent compensate for the germ-plasm deficiencies of the father.

In a word, prospective fathers have no grounds for being nonchalant about their diet. By the quality of their germ plasm they are as responsible as the mothers for the possible danger to the development of their children.

The idea of reinforcing the diet of pregnant women seemed self-evident once the laws of nutrition became known. Either for lack of natural elements or to permit the absorption of larger doses, the vitamins and calcium furnished have been sometimes synthetic.

Some interesting experiments in this area were conducted in an Ohio maternity hospital. Ninety pregnant women, divided into six groups, received added amounts of calcium, synthetic Vitamin D, and cod-liver oil, either separately or in combination. On delivery, children of the group receiving calcium and synthetic Vitamin D showed calcification of the kidneys and placenta, and complete closing of the fontanel. Labor was long and painful and the babies were oldish and ossified in appearance. When the women received only calcium, there was no calcification of the placenta or kidneys and the fontanel was only partially closed. When the mothers received only cod-liver oil, there was some calcification of the placenta but not of the kidneys, and the fontanel was partially closed. When the

mothers received no added food factors whatever, the placenta was very slightly calcified while the kidneys and fontanel were normal.

It is obvious that calcium and Vitamin D may not safely be administered haphazardly to a pregnant woman.

4 * GEOGRAPHICAL CONSIDERATIONS

I

The Research of Weston Price : The Swiss of the Lötschental and Visperterminen Valleys : The Eskimos and Indians of the Yukon : Melanesians and Polynesians; Masai and Kikuyu; Malays and Maoris; the Indians of Peru and the Amazon

The search for properly nourished peoples in order to compare them with the civilized has always been attractive to scientists. One of the few who have been able to contribute actual data to this field is Weston Price, the American stomatologist, who roved the world in his study of tooth decay, seeking human groups immune to dental caries. He found some among tribes living far from civilization, and methodically studied their way of life, particularly their diet. His conclusions are contained in his book *Nutrition and Physical Degeneration,* which has found a considerable audience in nutritionist circles.

He found that in the Lötschental Valley in the Bernese Alps the Swiss inhabitants were self-sufficient in both food and

clothing. They had almost perfect immunity to dental caries. Physically they are a handsome people, happy, much more concerned with spiritual values than with the material. The absence of draft animals imposes upon their men strenuous physical tasks. Their diet comprises black bread made from unbolted rye flour, cheese, fresh cow's milk and goat's milk, with meat about once a week.

The same conditions prevail in the Visperterminen Valley, except that here the diet includes wine. It must be noted that the butter in these regions is richer in vitamins, season for season, than the average butter made elsewhere. It is made from the milk of cows pastured in green valleys or stable-fed on green hay especially rich in chlorophyll.

On the other hand, in the regions around Saint-Moritz and in the vicinity of Hérisau and Saint-Gall, the diet is that of civilized peoples: bread made from bolted flour, jams, canned goods, meat, little milk. And despite the advanced state of public hygiene, these regions show a high rate of dental caries and a growing susceptibility to tuberculosis.

The Gaelic peoples living isolated lives in the Hebrides, off the northwest coast of Scotland, live chiefly on fish and foodstuffs made of oatmeal. They have a much lower rate of tooth decay and little tendency to tuberculosis—just the opposite of the inhabitants of the cities, who receive their food from the mainland and who thus follow a "civilized" diet.

The Eskimos have been on the rapid decline since fishing and hunting establishments have brought modern civilized eating habits into their lives. The few tribes still isolated live on fresh and dried fish, seal oil (extremely rich in Vitamin A), caribou meat, fish eggs, the organs of whales and other cetaceans, frozen nuts and berries, and sorrel preserved in seal oil. They also eat the inner layer of the skin of cetaceans, rich in Vitamin C. And although these Eskimos frequently have broken or well-worn teeth because of their habit of chewing leather before working it, they never develop dental caries or tuberculosis.

The Indians still living in a primitive state in northern British Columbia and the Yukon live on game and venison. They eat the organs of animals, particularly the suprarenal glands of the bear, which they find to be an antiscorbutic (it is indeed rich in Vitamin C). They break the bones to suck the marrow, and give the muscle tissue of their game to their dogs. They have perfect dentition, no arthritis and no tuberculosis.

Statistics show that when these Indians contract tuberculosis as a result of their introduction to civilization, the mortality rate drops to half when they are sent back to their primitive surroundings.

The Melanesians of New Caledonia and the Fiji Islands live in a warm, humid, tropical climate. They wear no clothes but rub their bodies with coconut oil which protects them against the rain and absorbs the ultraviolet rays. They eat fish—both salt-water and fresh—crabs, wild pig, fruits and vegetables. The race is considerably mixed with Chinese. Yet despite this crossbreeding—a cause of degeneration, according to many ethnologists—they are completely immune to dental caries as long as they stay out of centers of civilization and retain their ancestral diet.

Although the French colonies of the Marquesas Islands in Polynesia are being depopulated because they have taken to eating imported foods and consequently have fallen prey to tuberculosis and tooth decay, the inhabitants of the British Tonga Islands, farther from the trade routes, have maintained their primitive type. Their diet consists of fish, fruit and vegetables. During World War I, high copra prices brought considerable trade to the islands and with it the introduction of civilized foodstuffs. The health level began to drop at once. Lower copra prices, however, brought about a return to the primitive diet and improved teeth.

It would seem that Europeans cannot stand the climate of central Africa, particularly Kenya, for long periods. The climate itself may not be as responsible as the European diet. The natives, perfectly happy and healthy in their own envi-

ronment, weaken rapidly when they abandon their ancestral diet for that of the European.

The Masai particularly are tall, strong specimens. Normally they live on milk, fresh defibrinated blood, and meat. They have splendid teeth. Very intelligent, they make excellent doctors and veterinarians. They are mostly hunters or cattle breeders.

Their neighbors, the Kikuyu, live mostly by agriculture. The Kikuyu's principal food is yams, cereals, millet, beans, and bananas. They are not as big and handsome as the Masai and although they have fair teeth, they are more subject to dental caries than the milk-and-meat eaters.

Some of the tribes of Kenya eat insects, particularly large ants, and grasshoppers, either fresh in a kind of mush or dried for the winter.

All these blacks lose their immunity to tooth decay the moment they make contact with civilized life and adopt a European diet.

Some Australian aborigines live in arid regions to which the white man has never been able to acclimate himself. Those who live on the coast live on fish, shellfish and marine plants. Those in the interior eat game, legumes, roots, leaves, berries, grasses, and birds' eggs. This race, one of the world's most ancient, declines with frightening rapidity at first contact with civilization. Normally immune to dental caries and most diseases, when they leave their own way of life they lose their teeth and fall prey to infections of all types.

The Malayan and Asiatic peoples of the islands of the Torres Strait, north of Australia, live on fish, bananas, papayas, plums, and such tropical plants as taro. They are practically free from dental caries, although whites living in the same region have bad teeth and suffer from facial contractions.

The Maori of New Zealand are well developed and immune to tooth decay as long as they are faithful to their traditional diet of crustaceans, mollusks and fern roots.

The ancient Peruvians ate fish (along the coast) and plants

cultivated in river beds, or in the high plateaus through an advanced irrigation system. For meat they ate llamas, alpacas and guinea pigs. They grew much corn, beans, and potatoes. Their skulls unearthed by archeologists show solid bone formation and perfect dentition.

The Indians living today on the high plateaus of Peru have extraordinary strength and a remarkable resistance to intense cold. They have well-developed chests, good hearts, and strong face muscles. The rarefied air of the high altitudes is probably the cause of their respiratory development. They live on the meat of wild deer, llamas, alpacas, birds and vegetables. They eat few milk products. They have almost perfect immunity to dental caries.

The Indians of the Amazonian jungles also have excellent teeth on a diet of fish, birds and birds' eggs, fruits and vegetables and the farinaceous roots of the yucca.

To sum up, there are still people in excellent physiological condition in all climates. Is this due to nutrition alone? We should be imprudent to decide this *a priori.*

And yet these people belong to all races, even racial mixtures, and live under very different skies, so it would seem that their physiological good fortune does indeed derive from natural food and a natural climate.

But we should analyze further the chemical and biological characteristics of their dietary practices.

II

Protective Elements in Primitive Diets : Evolution of Skull and Body Form after Adoption of Modern Foods : Childbirth among Primitive Races : Natural Remedies for Tuberculosis, Xerophthalmia, Diabetes : Superiority of Fish-eating Peoples

The alimentary habits of primitive peoples are generally devoid of all prejudice. Many of their tastes are repugnant to civilized eaters. Most of them consider the eyeball a choice morsel to be offered to chiefs or distinguished guests. They are

also aware of the useful functions of various foodstuffs to their special conditions. Thus in one of the coastal highlands of Peru the Indians eat dried kelp, which is rich in iron and therefore aids their hemoglobin in taking up oxygen at the low pressures of high altitudes.

Primitive diets are also rich in protective elements. Price has made a comparison with civilized diets. Let us remember that the daily mineral requirements of an adult are .65 grams of calcium, 1.3 grams of phosphorus, and 15 milligrams of iron. Inasmuch as the human body absorbs scarcely half the active factors in foodstuffs, the actual mineral content should be at least twice the above amounts. And for special conditions such as illness, growth, pregnancy or lactation, most physiologists advocate increasing the dose fourfold to 2.5 grams of calcium, 5 grams of phosphorus, and 60 milligrams of iron.

The richness of primitive diets in these minerals is shown in Table II. It will be seen that natural foods contain five or six times the amount of phosphorus and calcium, much more iron, and ten times more fat-soluble vitamins. It should also be noted that the agricultural and sedentary cattle-raising tribes are less favored than the fish-eating tribes or those living by hunting or nomadic livestock raising. Price's world-wide observations demonstrate these last groups as the finest specimens.

In addition to studying the living peoples, Price also examined twelve hundred seventy-six skulls of ancient Peruvian Indians. He found no typical deviation of the kind found among whites or in the children of primitives who have adopted a civilized diet. The most striking of these deviations is a thinning of the median third of the head at the height of the nose. This deformation appears at the time of final dentition, from about the tenth to fourteenth year. The children of primitives who have adopted a civilized diet show other deformities such as flat feet and club feet. Often the whole body is more slender, giving the girls a boyish build. In the more serious cases the thorax becomes flat or hollow, denoting, according to Weissman, a predisposition to tuberculosis.

Table II

CONTENT OF PROTECTIVE FACTORS IN PRIMITIVE DIETS AS COMPARED TO THAT OF THE NORMAL WHITE CIVILIZED DIET, WHICH IS HERE REPRESENTED AS "1." *

	Calcium	*Phosphorus*	*Magnesium*	*Iron*	*Iodine*	*Fat-soluble Vitamins*
Eskimos	5		8	1.5	5	More than 10 times
Indians, Northern Canada	6	6	4	3	9	"
Lötschental Valley	4	2	2.5	3		"
Gaels of Hebrides	2	2	1.5	1		"
Australian bushmen	5	6	17	50		"
Maori	6	7	23	58		"
Melanesians	6	6	26	22		"
Polynesians	6	7	28	18		"
Coastal Indians, Peru	7	6	13	5.1		"
Andean Indians, Peru	5	6	13	29		"
Masai, Kenya	7	8	19	16		"
Agricultural tribes, Central Africa	3.5	4	5	16		"

It should be remarked that among peoples who have remained primitive, childbirth is of short duration. Doctors attached to Eskimo settlements report that they are always too late to witness an actual delivery among tribes maintaining their ancestral diet and way of life. Eskimo women who have adopted a civilized diet, however, are hospitalized and have labor pains sometimes lasting for days.

Price has noted also that primitive peoples are aware of the exhausting effect on the mother by too frequent childbearing. The Ibos of Nigeria consider it an "abomination" for a woman

* Weston Price's figures have been reduced to round numbers.

to have children oftener than every three years. In the Somali islands the husband is not allowed to have relations with his wife as long as the child does not walk, and "accidents" are condemned severely. Among the Indians of the Amazon relations between man and wife are suspended not only during pregnancy but during a long period of lactation, so that the children are at least two and one-half years apart. These Indians believe that the diet of the parents has a great influence on the delivery, the appearance and the character of the child.

Although the primitives are ignorant of the nature of vitamins, many of them know by experience that certain foods are able to cure some deficiency diseases. An American aviator forced down in the Rocky Mountains subsisted on canned goods while trying to find his way back to civilization. Stricken with xerophthalmia, he could no longer see well enough to travel. He had about given up hope when he met an old Indian who, when he understood what was wrong with him, caught several trout and fed him the eyes and retinal tissue. In two days the aviator's sight was restored.

Many primitive tribes have likewise discovered natural remedies for tuberculosis. In Australia and New Zealand the young of the muttonbird, taken before they have left the nest, are considered effective. In the Rocky Mountains the Indians use the glands of the male paddlefish to stop lung hemorrhages.

In Africa some tribes drink snow water and travel miles to eat iodine-rich aquatic plants to prevent goiter.

In British Columbia an Indian who entered hospital for an operation was found to have an advanced case of diabetes requiring massive insulin treatments. It was discovered that he had been a diabetic for years but had treated himself by drinking hot infusions of some spiny plant equally as efficacious as insulin, with the added advantage of being administered orally.

This knowledge of medicinal plants indicates that we should pay more attention to the practices of the primitives, generally

disdained. It should be noted, incidentally, that the so-called savage races are as secretive about their diets and their medication as civilized nations are about their armaments.

It is remarkable that Price found no peoples who had achieved physical perfection on an exclusively vegetable diet. Perhaps this is because Vitamin D does not exist in plants, whereas there are many sources of vitamins in the organs of animals, milk, the living products of the sea, and certain insects. The finest specimens of all were those who made wide use of the products of the sea.

The enumeration of all these examples may seem fastidious and monotonous, yet it is necessary to prove the relation between health and a primitive diet. And it is particularly satisfying to receive this indictment of modern diet from the pen of a citizen of the country which most admires a mechanized civilization.

5 * NUTRITION AND INTELLIGENCE

I

Carrel's Experiments with Quantity and Quality of Food : Influence of Diet on Student Activity : Vitamin E, the Pituitary, and Cerebral Development : Cranial Deformation in Mental Cases

Since diet has such a wide influence on the formation of the body, it stands to reason that it must also affect the psyche. Documentation on this point is rather rare, partly because of the survival of Cartesian ideas on the separation of mind and body, partly because direct human experiment is difficult and extrapolation from animal to man is questionable.

Working with colonies of four to five thousand white mice, inbred between brothers and sisters for several generations, Alexis Carrel found that those mice receiving a balanced diet rich in phosphorus were much more "intelligent" than those fed almost exclusively on seeds.

"Intelligence" was measured by the classic labyrinth test, in which the cleverest mouse was the one finding the quickest way through the maze.

Carrel also studied the influence of the quantity of food.

When the mice received unlimited food, they became heavy, passive, unintelligent, and less fertile. When the amount of food was cut to half of what they would eat if allowed to continue to satiety, the mice grew smaller, but more aggressive, alert, and very cunning. This would indicate that quantity of food has as important an influence on the psyche as quality. Carrel never found the time to publish these experiments, which present considerable interest if only for the strictness of his controls.

Price reports experiments carried on with rats of the same age without regard for their origins, so we presume that they had the same hereditary patrimony. One group fed on whole wheat developed normally. The animals were gentle in character and could be picked up by the ears and the tail without fear of being bitten. Another group raised on a diet of white flour exclusively were much less developed at the same age and suffered from tooth decay and skin troubles. They were so irritable and vicious that not only could they not be picked up by hand but they tried to attack the experimenters through the bars of their cages.

In the absence of strictly controlled experiment, some observations on men nevertheless furnish useful indications. Some children suffering from serious dental caries as the result of bad diet were treated by Price, who fed them on foods rich in the protective elements. Aside from the physical effects of this regime, the children rose from the bottom of their class to the very top, so that the teachers, intrigued, came to find out the cause of the radical change.

MacCollum reports that forty-two children in a single institution were given a quart of extra milk a day. Not only did they grow more rapidly than their comrades but they became more active, more intelligent, and more difficult to handle—to such a point that the authorities abolished the milk supplement in the interests of discipline.

F. G. Benedict, at Springfield College, Springfield, Mass., reduced the nourishment of eleven students to the point where

each lost 10% of his weight. For three months they were fed below the hunger level in order to maintain the reduced weight. They then showed a below-normal capacity in each of the following tests: tracing a straight line, judging the pitch of a sound, addition, sensitivity to electrical stimulation, rapidity of eye movements and hand movements, maintenance of normal pulse during work. Other aptitudes, such as sharpness of vision, memory, or the choice of the best route through a maze, were not affected. We can only guess what results might have developed from a continuation of the experiment. It is possible that a weight difference of this proportion may not have an appreciable psychic influence. Moreover, it is probable that intellectual activity would be more affected by small differences in the quality of food than by the quantity. Benedict also noted a lowering of sexual interest in his undernourished subjects, an interest which rose sharply as soon as they were again permitted to eat all they wanted. This may explain the revival of sexual instinct in animals and primitive peoples when food becomes plentiful again after the privations of winter.

Physiologists are agreed that all these manifestations are under control of the pituitary gland. The influence of the pituitary on the shape of the head has been studied systematically in Canada by Dr. Mortimer and his collaborators. Removal of the gland in rats causes a regular deformation of the skull, marked by a lack of forward development of the snout, a contraction of the nostrils and a narrowing of the dental arch. These defects do not appear when the animal, after operation, receives pituitary extract by injection. Radiological study of humans with pituitary tumors show similar deformation of the skull. All of which seems to indicate that the shape of the skull is controlled by the pituitary. This gland, this conductor of the endocrine symphony, is affected by a deficiency of Vitamin E, as was noted earlier.

These anomalies of the skull and consequently of the face are frequently encountered among mental defectives. Ac-

cording to the statistics of Sir Thomas Clouston, the frequency rises from 19% in normal individuals to 55% in criminals and 61% in idiots. Still more explicit is Petersen, who, after extensive research, concluded that skull deformities occur in 82% of mental defectives, 76% of epileptics, and 80% of the insane. Price, after examining one hundred eighty-nine predelinquent Americans, found only three—less than 2%—had normal teeth, while many had seriously deformed faces. Examination of children in a school for the mentally retarded revealed that 97% had malformation of one or both jaws.

Still more general observations prove that retarded children, predelinquents, and precocious criminals have many physical points in common. According to May, the tongue has a tendency to be too wide for the mouth. This is also a characteristic of the Mongolian idiot, whose other anomalies, much more serious, render him unfit to care for himself.

These deformations of the face are not fully revealed until the children acquire their normal dentition, and it seems that at this point there is a general regression in all individuals. Lichtenstein and Brown have in fact declared that the intellectual coefficient of deficient children curves downward from the tenth to the fourteenth year, which is the period at which the physical malformations appear. Moreover, these do not seem to be caused by malnutrition but rather date back to conception and fetal life.

Sociologists insist that a disturbing increase of mental illness is general in our white civilizations. This may be because the nerve tissues are the most delicate of all during fetal life and would be the first to be attacked. The fragility apparently reaches its maximum during the fourth week of the embryo.

One typical experiment, not at all unique, incidentally, shows the connection between the shape of the skull and the psyche. The subject was a Mongolian idiot, born of an aging and tired mother. At sixteen, he had the organs of a child of eight. His left nostril was completely obstructed, and he had to breathe through his mouth. His mental age was no more than

four years and he played like a baby. His upper jaw was so underdeveloped that it fitted inside the lower. To improve his condition, Price decided to widen gradually the upper jaw by 12 or 13 millimeters with the aid of proper apparatus. As the operation progressed, the patient showed great change, both physical and moral. He grew three inches in four months. His beard began to grow and his genitals became those of a man. During the same period he showed a sense of shame for the first time. In a relatively few weeks his body compensated for years of retardation. He gave up his childish games and was able to lead an almost normal life. When his prosthetic apparatus became accidentally unadjusted and the jawbones contracted again, he became mentally disturbed. Readjustment of the apparatus restored order in a few days. Despite his intellectual growth, which allowed him to learn to read, his conscience remained that of a child, unfortunately. Finally, when he could no longer be watched by his family, the disharmony between his advanced physical development and his backward moral sense threatened to make of him a sexual pervert needing constant surveillance.

That these malformations, and hence these psychic deficiencies, may be traced to the diminished reproductive powers of the parents, particularly of the mother, is indicated by the greater frequency of such defects in the last-born of large families.

If some moral defects are the result of a malformed skull which in turn has been caused by malnutrition of the parents, why must civilized society be so determinedly pitiless toward the wrecks for which it is itself responsible? And how can governments which tolerate the advertising of alcohol have the effrontery to condemn the victims thereof through their own courts?

II

Comparison of Neighboring Tribes with Differing Diets : The Masai and Kikuyu in Africa : The Sikhs, Pathans, Mahrattas, Gurkhas and Bengalis in India : Food and Martial Valor

Some biologists have tried to analyze the influence of diet on the psyche by comparing neighboring tribes who eat different foods. One classic study was made by John Boyd-Orr and J. L. Gilks in 1931, balancing the Masai and the Kikuyu of the Kenya plateau in east-central equatorial Africa.

The Masai are a nomadic tribe of hunters who are sometimes pastoral. As previously noted, they live mainly on milk, meat (preferably the organs), and the blood of animals. The Kikuyu, a settled people, farm and raise livestock. They eat bananas, beans, corn, millet and potatoes. Their diet is rich in carbohydrates, but poorer in vitamins and protective elements than that of the Masai. The two tribes are different physically, too. The Masai are six or seven centimeters taller on the average and some twenty pounds heavier. But their most marked difference is mental. The Masai are reputed to be hardy hunters and warriors, of rare courage and great nobility of character. The Kikuyu, on the other hand, are of questionable loyalty and bravery.

Boyd-Orr and Gilks attribute these differences to nutrition. However, since the two tribes differ racially and since the Masai live on a higher plateau in a colder climate, these two factors cannot be summarily ruled out.

Be that as it may, Price found only four Masai with decayed teeth out of eighty he examined, and the total percentage of defective teeth was less than .4%. Examination of thirty-five Kikuyu, however, turned up fifty-five decayed teeth—a percentage of 5.5 concentrated in 36% of individuals examined. On this point, the influence of diet seems incontrovertible.

Another more extensive study was made by R. McCarrison among the peoples of India. He raised rats with similar hered-

ity, divided them into seven groups and fed each group on the typical diet of one of seven peoples of India. After two and one-half months, he weighed the rats and rated the respective diets according to increase in weight. The classification of the Indians was: Sikhs, Pathans, Mahrattas, Ghurkas, Kanarese, Bengalis, Madrasis.

The diet of the Sikhs, top of the list, comprises grains, milk products, vegetables, and occasionally meat and eggs. That of the Bengalis, next to last, consists mainly of rice and is thus deficient in proteins, fats, vitamins and minerals. The deficiency is aggravated by washing and polishing of the rice, but the diet luckily contains a little milk although only about one-sixth as much as is consumed by the Sikhs.

McCarrison found the Sikh diet so satisfactory that he fed it to all his experimental rats. During the next five years there was no illness, no abnormal births, and no infant mortality among his thousand or so rats.

He later fed one of his rat groups on the diet of the poorer classes of England: white bread, margarine, well-sugared tea with a little milk, cabbage, boiled potatoes, boiled meats, and so forth. The diet is characterized chiefly by its deficiency in vitamins and minerals. While the rats eating the Sikh diet grew fat and sassy, the other group was badly proportioned, did not gain weight, and developed nervous characteristics. They fought among themselves, tried to bite the experimenters, and after sixty days began to kill and eat the weakest among their own group. Finally they had to be separated. After one hundred ninety days, a period corresponding to sixteen years in the life of a human, the rats were killed and autopsies performed. Among the rats of the English group there were cases of beriberi and lesions in the lungs, stomach and intestines. The rats eating the Sikh diet showed no pathology except traces of pneumonia, and only to a much less degree than the others.

The diseases found in the rats are repeated among the peoples of India in about the same proportions, so that McCar-

rison concluded: "The level of physical deficiency of the various races of India is essentially of nutritional origin, other factors apparently having much less influence."

When the British were administrating the Indian army, they rated the Indians in the following order:

Sikhs—Very good soldiers, loyal, faithful, and brave.

Pathans—Nomads, but also very good soldiers.

Gurkhas—Very good, courageous, and disciplined.

Mahrattas—Slightly less good.

Bengalis, Kanarese, and Madrasis—Bad soldiers, apathetic, unfitted for war.

It is remarkable that this classification, based on the valor and moral qualities of the individual, coincides essentially with the list rating the relative values of the seven diets. And even more conclusive is the fact that although the Bengali masses are less than mediocre, their well-fed ruling classes are on the contrary very alert mentally.

Strictly we must also take into account racial and climatic factors. The Sikhs and Pathans have the best heredity, although we cannot be sure to what extent this is due to their ancestral diet. Ellsworth Huntington rates the climate of the seven peoples in the following order of decreasing favorability: Ghurkas, Pathans, Mahrattas, Sikhs, Bengalis, Kanarese, Madrasis. The classification of general worth is closer to the diet rating than to that of climate, but it is all more or less related. The milk of the Punjab, land of the Sikhs, is superior to that of the hot and humid climates of Bengal or of the southern Indian regions of Madras and the Kanarese. Besides, these latter peoples are handicapped by the religious interdiction against the eating of meat.

The researchers conclude their study in recalling the old maxim: "An army marches on its stomach." But inasmuch as we have shown in earlier chapters that human qualities depend also upon the nourishment of the parents, it would be more exact to say: "An army marches and fights with its own stomach and that of its forefathers."

6 * CONCLUSION

I

Acid-Alkaline Balance : Vitamin A Deficiency and the Nervous System : Seasonal Variations in Vitamin Content : Diathesis and Morphology

The human body is made up of some twenty elements already enumerated and the list grows longer as our means of analysis improve. Some are essential in minute quantities only, while others like calcium and phosphorus are more abundant.

The classical theories all point out the need for maintaining the balance between acid and alkaline foods but Weston Price's Eskimo experiments seems to invalidate this. The Eskimo diet is largely animal and therefore acid and yet it produces the same happy results enjoyed by other peoples whose basic diet is milk and vegetables. It may be that a diet that is essentially meat is better suited to peoples leading an active life than to sedentary and civilized folk whose regulative systems are less stimulated.

The action of each of the vitamins is much more widespread and diffuse than formerly supposed. For instance a Vitamin A

deficiency during gestation may cause not only blindness in the embryo but a degeneration of the central and peripheral nervous systems as well as hearing defects ranging up to total deafness. In the most serious cases it may cause miscarriage even though there is no Vitamin E deficiency. In adults the A deficiency may induce deterioration of the epithelium of the genital cells, especially in the male.

Biological questions are always complicated by more extensive study. Vitamin B, for instance, has "exploded" into a dozen factors. And according to C. E. Bills, Vitamin D will ultimately be broken down into at least eight and probably twelve distinct elements.

But the elements will probably be interrelated, just as everything else in the human body is linked together. Thus the absorption of calcium and phosphorus from foods depends upon the presence of fat-soluble vitamins. The mineral elements in skimmed milk cannot be assimilated unless the milk is accompanied by other foods containing fat-soluble vitamins to replace those skimmed off with the cream. The power to synthetize vitamins within the body is not quite extinct in man, at least as far as Vitamin D is concerned. But he is not self-sufficient in this respect, as are the dog and the guinea pig. No matter how much sunshine or ultraviolet rays he absorbs, he must still have recourse to food to make up his full quota.

At one time it was thought that Vitamin D could be obtained in sufficient quantities from vegetables, but today we look to animal foods as its chief source: seafoods, milk products, and the internal organs of animals.

Contrary to some current opinion, however, the richness of vitamin content is independent of fat content. The vitamin content of milk varies widely from region to region and from season to season. Butter which is richest in vitamins is regularly produced by cows grazing in growing grass, and especially on wheat, rye grass, oats and barley. A diet which includes vitamin-rich butter of this type prevents tooth decay and reinforces general vitality. The vitamin content of eggs is

also determined by the diet of the hens, which also has some influence on the percentage of fertility in the eggs.

Cattle breeders do their utmost to produce births at a favorable time of year. Calves raised on milk from cows who are eating dry hay, poor in chlorophyll, develop badly. Those who are suckled by cows grazing on young grass, especially sprouting wheat, grow much more rapidly and are healthier. Grass, too, varies from place to place, and where the soil is poor in minerals and protective elements, the cows do poorly, particularly during gestation and lactation.

The annual curve of human mortality rates reaches an unquestionable peak at the end of the winter and the beginning of spring. The peak varies by a month or so according to latitude. When death is due to maladies caused by chilling, the peaks may be explained by changes in temperature. Price, however, puts forward another factor. He points out that the curve representing the vitamin content of butter (criterion for the general proportion of protective elements in foodstuffs) inversely follows the mortality curve. Even the curve of deaths from heart disease shows the same peaks and lows, a phenomenon that can hardly be explained by temperature. It would seem, therefore, that the resistance of the body to functional disease as well as to illnesses due to "catching cold" is at its lowest when foodstuffs contain the least protective elements.

Thus we have a statistical explanation for the fact that a teaspoonful a day of cod-liver oil mixed with butter oil obtained by centrifuging butter at 68° F. will, when divided among three meals, give great immunity against *à frigore* maladies, while preventing dental caries and maintaining an excellent state of general health.

Another conclusion to be drawn from these studies is the close relationship between moral health, physical health and general morphology. An old general practitioner can usually recognize by examining the shape of his patient his predisposition to certain diseases. When diet changes, the change is reflected in the morphology of the body, particularly of the face.

These changes often indicate the susceptibility to certain diseases. The predisposition to tuberculosis, for instance, appears in a tightening of the nostrils, the lengthening of the face, and the contraction of the middle third of the face.

All are closely linked—a man's health, his physical appearance, and his psyche. Thus morpho-pathology, psycho-morphology, and particularly physiognomy are based on solid foundations. This relationship is evidently not confined to man. Breeders and experimenters can judge the character of an animal by its outward forms.

But how can we admit, without false shame, that human thought and character may be linked to material form?

Thirty years ago learned professors of philosophy gravely told their students that phrenology was only a pseudo-science because the morphology of the head could no more reveal the mental faculties of its owner than the shape of a violin case could hint at the qualities of the instrument inside.

The funny part is that we were so imbued with the dogma of independence of mind from body that we actually fell for this puerile reasoning.

II

Primitive Beliefs and Nutritive Principles : Formation of Tastes in Children : Sugar and White Flour

There is physical basis for such primitive beliefs as eating the brain of an enemy to become intelligent, or eating his eyes to improve one's vision—at least to the extent that a man thinks with his brain. Each organ has its own special composition. The eye, for instance, is rich in Vitamin A, the liver in Vitamin D. Why, therefore, should not the eating of an organ be a specific corrective for a deficiency in the corresponding human organ?

The building of the human body is accomplished more

easily with animal food than with vegetable, since the constituents are more nearly alike. That is why peoples living by agriculture alone are inferior to nomadic herders, hunters, or fishermen.

Whatever his metaphysical origin, man is an integral part of nature. The proof lies in the similarity between the nutritional needs of man and other mammals. The human being has been formed by the diet of the first men, millions of years ago, and there have been no important changes in form since. The exigencies of his body are not greatly different from those of most animals. He has no right to arbitrarily violate the laws of nature.

The characteristics of the nutrition of primitive man may be summed up as follows:

1) Man eats plants or animals or both, according to season.

2) His meal usually derives from a single element, although all parts are consumed, even the hard portions or the least tasty, even to the marrow of the bones.

3) All food is eaten fresh, often raw or barely cooked.

4) Vegetables are eaten as soon as they are ripe enough, with the exception of some fruits and seeds, like nuts, which can be stored for winter use.

5) Primitive man is without the queasy dislikes of civilized man. He eats insects and mollusks as well as the muscles of large animals. And he prefers the internal organs to muscles in any case.

6) His intervals between meals are extremely variable. He may go without food for a few hours or a few days, depending on the needs of the moment. And it may be noted here that recent researches by Haagard and Goldberg have shown that the maximum efficiency of physical work by man is attained with frequent small meals.

It is highly important, therefore, that civilized man revise his nutritional habits. It will be a difficult reform because he has acquired a taste for the wrong foods. And since food tastes are formed in childhood, it is essential that children be taught

to like dishes rich in the protective elements to the exclusion of a surfeit of white flour and sweets in all forms. Experience has shown that the development of healthful tastes presents no special difficulty.

The dangers of excessive pure sugars and bolted flour are not imaginary. Sugar contains practically no protective factor; it is an almost pure fuel. The protective elements must therefore come from elsewhere in the diet. But civilized man's physical activity has been so reduced that he gets all his energy requirements from sugar and therefore has no appetite for his other needs. This is especially serious in children. A child would have to eat the equivalent of 30,000 calories of jam—an adult's caloric needs for ten days—in order to obtain one day's requirement of the phosphorus needed for his growth.

The same is true for white flour, which loses 80% of its calcium and phosphorus in bolting, to say nothing of the wheat-germ vitamins. Drumont has shown that a falling birth rate invariably accompanies changes in the milling industry—the replacement of whole-wheat by white flour without the bran and germ necessary to health and reproduction.

A man of normal activity should confine one-third of his caloric intake to protective foodstuffs. Price's statistics show that the peoples in best physical condition consume a much higher proportion of these elements. The research of Striebling and Ware puts the essential proportion at one-half at least, far more than most civilized peoples now consume. In China, according to John Buck, the proportion is only 4%—a frightening indication of the extent of nutritional deficiency in that country.

III

Another Look at Questions of Heredity : Growth of Degenerative Diseases Among Sedentary Peoples : The Decline of Civilizations : Fitting the Population to Soil Resources

One of the consequences of so much research is the need to "rethink" our answers to questions of heredity. The current tendency is to attribute all defects and malformations to congenital* causes. Now if we consider the brain, for instance, its defective development may be due to a somatic taint of the germ cells or to an accident of intra-uterine life, as well as to heredity.

In essence, abnormal environmental conditions may inhibit the normal play of the hereditary processes by an alteration in the germ plasm. This conclusion does not contradict the classic laws of genetics; it simply calls for caution in imputing causes for malformations. Some investigators have attributed these defects to an unharmonious mixture of races. Overlapping teeth, they say, result from the heritage of a narrow jaw from one parent and too wide teeth from the other. Actually, crooked teeth may more simply be attributed to faulty nutrition of the parents, particularly the mother during gestation.

It is dangerous to upset the balances created by nature. The mineral elements in the soil are only loaned to living things, plant and animal. When the living animals are removed, and neither their excrement nor their mortal remains returned to the soil, the soil is fatally impoverished. This happens when the waste products of life are carried out to sea by the sewers. The protective elements drawn from the soil by plants become rarer and rarer.

It is normal, therefore, that intensive exploitation of the soil, without regard to replenishing its protective factors, should be

* The term needs precise definition. Etymologically, "congenital" means "engendered with." Thus in the sense of modern theories of heredity, it concerns only the genes and chromosomes.

followed by an increase in diseases of degeneration. One of the most striking examples of this comes from the United States. According to the statistics of the American Heart Association, the curve of deaths from heart disease varies directly with the age of the civilization of each state. Between 1920 and 1930 the average American death rate from cardiac disease rose from 50 to 80 per cent. Other causes than soil impoverishment may of course be involved. All mortality-rate statistics must of course be approached with caution because technical difficulties and psychological considerations may influence diagnoses. Nevertheless, all other things being equal, it is generally admitted that cardiac disease is more frequent in communities which have adopted the modern way of life, a fact particularly striking in the United States.

Soil changes, and hence nutritive changes, are one of the current explanations of the disappearance of civilizations. At least they play an important part. It is worth noting, as a matter of fact, that when civilizations have survived for long periods, their arable soil has been regularly renewed. The classic example is that of Egypt, periodically replenished with silt carried from the high plateaus by the Nile. The same is true of China, in the valleys of the Yangtsze and the Yellow River. We must admit that in some cases impoverishment of the soil is not due solely to exhaustive abuses but to deforestation which allows the wind and rain to carry away much of the top soil. But whether by erosion or by overexploitation, soil exhaustion is today perhaps the greatest menace to American civilization.

It is true that modern transport is very different from that of extinct civilizations, and it is not impossible to envisage the feeding of some populations with imported foodstuffs. Many primitive races have already organized analogous systems despite the paucity of their means. In some Pacific islands, a pregnant woman reports her condition to the tribal chief, who, after the traditional rites committing the tribe to adopt the future child should he ever become an orphan, designates

several young men to go to sea daily in quest of proper food for the mother during gestation and lactation.

In civilized countries we must relapse into the penury and barbarism of war before public authorities bother to provide expectant mothers with special nourishment.

One of the most distressing of these conclusions is the need of restricting populations to the possibilities of rational nutrition. Often the estimates of maximum populations are based solely on resources in energy foods, an error which can produce disastrous results. A commission of experts gathered by the League of Nations once calculated the *per capita* needs of land in proportion to population as follows: 0.6 acres for wheat, 2.25 acres for dairy products, 10 to 15 acres for pasturing meat animals. These figures would naturally have to be calibrated according to soil values, but they show that with our present knowledge and means of production, our population growth must be strictly limited.*

Overpopulation invariably leads to conflict and to wars. This sad denouement has a double cause, for malnutrition also engenders moral degeneration, source of the most catastrophic adventures. It is not an accident that Price in his travels was struck by the moral strength and integrity of the primitive peoples, well fed and in fine physiological fettle. Never did they give him the slightest cause for worry and never was his confidence in them betrayed.

Here is food for thought by sociologists and moralists.

* These pessimistic conclusions may be only temporary. Man is now actually exploiting only a small part of the world's resources, particularly the scarcely known nutritional riches of undersea life. Besides marine vegetation, there is a vast, still-unknown fauna which lives off the dim pastures of the great depths and off the tiny living organisms that make up the plankton.

7 ⁎ STANDARDS OF LIVING IN VARIOUS COUNTRIES

I

Geographical Considerations : Evolution of Living Standards in India and Japan with Growth of Population : Diet Variations between Social Strata in England

India offers a striking illustration of the influence of population growth on nutritional values. The Indian nationalists blame the British *raj* for having added to the misfortunes of an unfortunate country. Britons reply that with great public works they have raised the general health level of the country, decreased famine, and abolished arbitrary death penalties.

Both are right. By their humanitarian measures, the British administration added greatly to the population of India, which in three centuries has grown from one hundred million to more than three hundred fifty million. But they have not increased production in the same proportion during the same period, so the actual standard of living has really dropped.

The history of India shows, incidentally, that the most prosperous and brilliant periods have always been preceded by wars, famines, or epidemics which decimated the population but left the survivors with more food *per capita.*

The same is true of Japan. Its most calamitous years have been followed by periods of prosperity and production. And the overpopulation formerly absorbed by epidemics now leads to war or emigration. Although the Japanese are skillful cultivators of the soil and produce unequaled crop yields, Japanese scientists recognize that the average diet for their nation is one of the worst in the world. The Japanese often have bad teeth and deformed jaws. One-third of the population wears glasses. Malnutrition explains some of the deficiencies of the Japanese soldier during World War II. Although better fed than his civilian compatriots at home, he was handicapped by his previous malnutrition. He did not stand up as well in the tropics as his British and American adversaries. Japanese airmen were particularly handicapped by their bad eyesight, heritage of Vitamin A deficiency in their parents.

This example is not an isolated one, and a technical commission from the League of Nations in 1938 compared the average quantities of protective foods consumed by various countries per year *per capita* (Table III).

Table III

Milk and Dairy Foods (liters)		*Meat* (kilograms)		*Eggs* (units)	
Japan	5	India	½ to 1	Egypt & Russia	40
Romania	90	Italy	15	Holland	100
Poland	220	Sweden	35	U.S.A.	200
U.S.A., Belgium & Germany	350	U.S.A. & Britain	60	Canada	300
Finland	650	New Zealand	105	Ireland	400

Colin Clark calculated the cost of feeding the average man in a dozen different countries, valuing the products (in dollars) according to their prices in England about 1930:

China, India	less than $20
Japan	$22
Russia	$23
England, Germany	$50
France, Switzerland	about $60
U.S.A., Australia, Scandinavian countries	$64
Canada	$76
Uruguay	$77
New Zealand	$81
Argentina	$88

The above figures represent both quality and quantity, inasmuch as the foodstuffs high in protective elements are the most expensive. In the less favored regions, quantity and quality are both deficient. The survey found that an average of less than $60 *per capita* indicated malnutrition, which would have us believe that England and Germany were both improperly fed at the time the survey was made.

The statistics concern only the average, but in all countries there are great differences in diet according to social level. When the average is barely good, the lower classes are certainly eating badly. So Clark also compared the diets of six social strata in England, ranging from the poorest to the most prosperous (Table IV). Each of the two extreme groups comprises 10% of the population, the intermediate groups 20% each.

The last column represents the ratio between poorest and richest strata in the consumption of each type of food. You will note that although the richest eat 10% less nonprotective foods, such as cereals, they eat three times as much of the protective factors such as milk, fruits and vegetables.

Commenting on these figures, Huntington estimates that category IV of the Clark survey table represents about the average American. The average Briton or German would place between groups II and III. The average Russian or Japanese would rank much below group I and the Indian or Chinese lower still.

Basing his conclusions on Clark's figures as well as those of Bennett, Huntington has drawn up a further classification of countries according to diet, dividing them into eight groups in descending order:

A. New Zealand, Canada, United States, Australia.
B. Switzerland, Great Britain, Argentina.
C. Sweden, Belgium, Denmark, Norway, Germany, the Netherlands, France.
D. Austria, Finland, Czechoslovakia, Ireland.
E. Esthonia, Mexico, Chile.
F. Italy, Algeria, Bulgaria, Egypt.
G. Japan, India, Romania, Java, Russia.
H. Philippines, China.

In view of the arbitrary criteria adopted in making this list, the rating must be viewed with some caution. Argentina, for instance, rates high because it is a big meat consumer, yet its national diet would be much improved by the addition of more fruits and vegetables. Furthermore, the list makes no allowance for varying vitamin content of the same products from country to country. Although cereals, milk, eggs, butter and fruits may look the same, Carrel has demonstrated that mass production changes their composition. Wheat forced by artificial fertilizers cannot have the same protective value as natural-grown wheat on naturally fertile soil. Dietary habits also disturb calculations, for the degree of bolting varies from country to country. The relatively unfavorable rating of the Soviet Union is surprising in view of the behavior of the Russian soldiers during the last war. Huntington explains this by the fact that the Red Army was far better fed than the civilian Russian population. Moreover, it is difficult to get accurate information out of the U.S.S.R.

In a more recent study (1946), Irene P. Taüber made an interesting comparative study on the nutrition of various countries. In addition to the number of calories consumed per day *per capita,* this study showed the percentage of calories deriving from cereals containing few protective factors. She also

Table IV

ENGLISH DIET ACCORDING TO SOCIAL STRATA

Approximate Annual Cost of Food Per Person According to Colin Clark (in dollars)

Food	*Social Strata: Poorest—I; Richest—VI*						*Ratio of I to VI*
	I	II	III	IV	V	VI	
Cereals and cereal products	3.40	3.50	3.50	3.50	3.40	3.10	0.91
Potatoes	2.60	2.70	2.80	2.80	2.80	2.60	1.00
Sugar	1.90	2.20	2.50	2.70	2.80	2.90	1.52
Tea, etc.	2.10	2.60	2.80	2.90	2.80	2.60	1.24
Total, non-protective	10.00	11.00	11.60	11.90	11.80	11.20	1.12
Milk and dairy products	6.90	12.70	14.80	16.80	19.20	21.90	3.18
Meat	12.40	16.80	19.80	22.30	24.20	26.40	2.12
Eggs	1.40	2.00	2.50	3.00	3.40	4.30	3.07
Fruits and vegetables	2.10	3.80	5.60	7.80	10.30	15.10	7.20
Total, protective foods	22.80	35.30	42.70	49.90	57.10	67.70	2.96
Grand total	32.80	46.30	54.30	61.80	68.90	78.90	2.40

made a breakdown by annual income and mortality rates, clearly demonstrating that below a certain level mortality is closely linked to the quantity of food consumption. Mortality is also dependent upon national hygiene, which is also related to the prosperity of the country—in other words, to annual average income.

Among peoples whose daily average food consumption is more than 3,000 calories, France and Ireland rate highest in proportion of cereals to the rest of the diet. These two countries also have the highest mortality rate. Is this because cere-

als are low in protective-factor content? Or is their national level of hygiene below that of the richer countries?

Present-day England, by a heroic effort, has submitted to a regime of restrictions which affected the national diet for many years after the war. It is to be hoped that this prolonged Lent will not compromise the future. The future of a country depends upon its children and adolescents, who must be correctly nourished.

8 ⁎ RHYTHM OF GROWTH

I

Man's Loss of Maximum Food Instinct : Obesity, Human Creation : The Weight Curve in Growing Children : Longevity and Quantitative Diet

Man has not only lost his instinct for eating quality food, he has also lost his quantitative instinct. Perhaps this is due to the fact that most civilized trades and professions require less and less physical activity. The same loss is apparent to a lesser degree in domesticated animals and even more so in house pets. In cattle of course obesity is deliberately induced to increase the market yield. In pets, it is the result of an inactive life and a diet too rich in carbohydrates. Look at any spoiled city dog.

At liberty in nature, animals always keep their graceful lines. True, in summer they store up a reserve of fats for the winter, but they never lose their shapes. The ugliness of obesity is strictly a human creation.

Surprisingly enough, the optimum rhythm of human growth has practically never been thoroughly studied—which shows how retarded are the sciences of man. Treatises on the care

and feeding of children, more or less influenced by commercial interests, usually go no farther than ratifying weight figures corresponding to the well-fed average. But the subject matter is subject to caution. Like a mother who fears the cold for her child and induces overheating (a subject we shall discuss in connection with the work of Carrel and Baccino), she also is apprehensive of undereating. Most of the time she forces the child to eat beyond his normal appetite. Just as we have forgotten the optimum temperature for the suckling babe, so has the instinct for proper feeding become lost in the night of time.

Preoccupied with this question, A. de Malleray, father of a large family, has tried to reconstruct a curve showing the optimum growth of children and adolescents (*figure 1*). Although the classic pediatric tables equate weight with age, Malleray judiciously compares it with height, a variable in children ac-

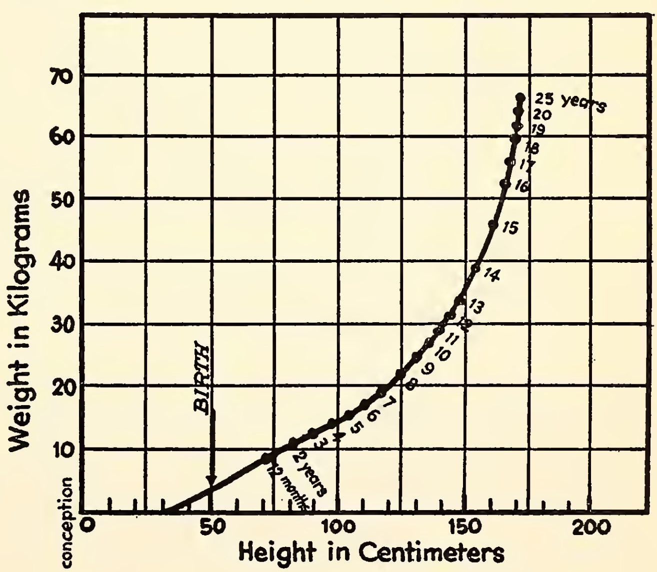

Fig. 1: *Statistical curve of growth of males from conception to age 25 in relation to height. (A kilogram is 2.2 pounds; 2.54 centimeters equal one inch.)*

cording to their heredity. The curve is convex from birth to three years, slightly concave to about five years, a phenomenon which bothered Malleray. Unable to justify it physiologically in humans, he drew growth curves for various animals: rabbits, fish, calves, horses, rats, birds, and others. All his animal curves showed great regularity, without the variations he found in his curve for humans (*figure 2*).

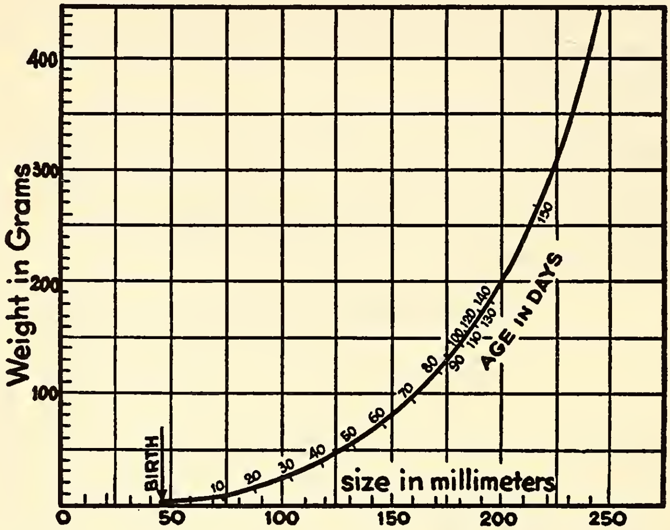

Fig. 2: *Statistical curve of the growth of rats from birth to about 150 days, in relation to size. (From Henry Donaldson's* The Rat.) (*One ounce is 28.35 grams; one inch is 25.4 millimeters.*)

He noted further that the growth curve for the human fetus from conception to birth is exactly similar to that of animals, but that a deviation began immediately after birth.

In later studies, based on the weights of adolescents according to the classic canons, and deliberately deviating from the modern idea that a child is well built when well padded, he drew a theoretical curve of human growth, inspired by the animal curve, showing that by actual weight children are too fat from birth to five years and too thin thereafter (*figure 3*).

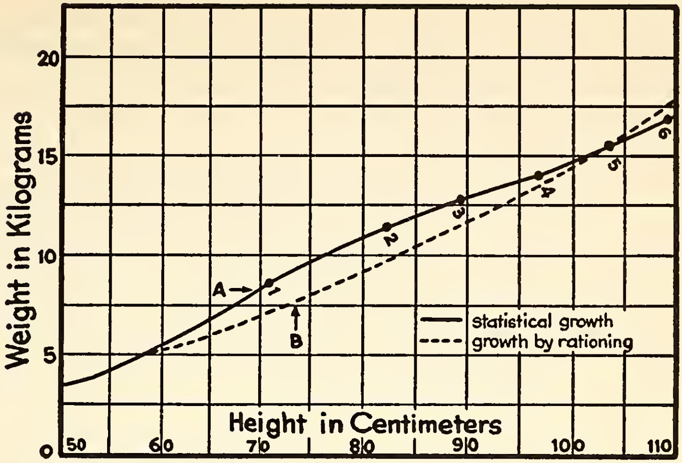

Fig. 3: *Growth curve for males to the age of six years. A represents actual growth. B represents theoretical growth by rationing. (A kilogram is 2.2 pounds; 2.54 centimeters equal one inch.)*

Further experiments demonstrated that children who are stuffed by overfeeding before the age of five will invariably be underweight between the ages of ten and fifteen despite all efforts at overfeeding. The difference between the actual weights and the theoretical weights was plus four to six pounds at three years and minus the same range between the tenth and fourteenth years.

Malleray decided he would raise his seventh, eighth, and ninth children by keeping their weight to the theoretical curve. He noted their superiority over their six older sisters and brothers in many fields: better general health, greater resistance to infectious diseases, better nervous equilibrium, absence of uncontrolled boisterousness and groundless fears. Malleray concluded that most children were overnourished in their early years, leading to general strain on the whole system and fatty invasion of the tissues. He also gave the opinion that this overfeeding, acting on the budding psyche of the child, would impress him permanently with a false norm.

If we accept the conclusions of Tallarico and J. McCay, who

link longevity to the period necessary to double the weight at birth, the later Malleray children and those similarly raised should all be centenarians.

Scientifically, the work of Malleray calls for the following observations:

The diet of the children thus fed experimentally was reduced rationally—that is to say, the level of the protective factors was kept high, and even increased at the expense of the glucosides. The three children fed in this way were thus better nourished than their elders. However, as Malleray himself points out, observations made on a basis of only three children are obviously insufficient basis for a new theory. Nevertheless, it must be remarked that these happy results were obtained with the last children of a very large family, the issue of parents who were both past forty—very unfavorable conditions, if we accept the conclusions of earlier chapters.

The theory must evidently be tried out on many more children. But it is a long wait if we must observe the whole life cycle to report total results.

Experiments with animals are difficult because of the necessity of forcing your animals to eat beyond their hunger point. They cannot prove that man does not have his personal growth curve, but they may show how overfeeding influences longevity and the general behavior of animals.

It would also be interesting to study the growth curves of children of the primitive peoples studied by Price, to say nothing of experimentation with true twins, one stuffed with food, the other rationed.

If in most countries the poor are often undernourished, the rich on the other hand generally eat too much. Probably this overfeeding is one of the causes of the decline of the privileged classes.

There is no doubt that excesses of all kinds—eating in particular—put a strain on the system. The unused calories are stored in the form of fat, increasing both weight and metabo-

lism. Excesses also have an influence on longevity. Mendel and Osborne, depriving young rats of the amino-acids necessary for growth, effectively slowed their development but increased their life span. B. S. Crowell and McCay, experimenting on a basis of quantity instead of quality, fed their rats a balanced diet but in insufficient quantities. The underfed rats lived 60% longer than normal rats.

Among the lower animals, rejuvenation has been achieved through diet. Numerous researchers have discovered that alternate fasting and feeding will produce an increase in weight greater than that lost. Reducing the amount of nourishment seems to induce more efficient utilization of available calories, and when feeding becomes normal again, all body activities, particularly sexual ardor, are stimulated. So the fasting periods imposed by religions before the return of the best days for procreation seem well justified by biology.

Although we lack precise information on quantitative feeding, all experiments point to its importance. Human instinct is no longer a reliable guide. We must define the mean in terms of height, activity, and climate. The question raised by Malleray does not stop with childhood. Perhaps wartime rationing was beneficial for those who were at last enabled to balance their diet.

"Man digs his grave with his teeth . . ." the explanation of which might be likened to the fatigue of an overfed organism showing premature wear as does the motor of a car pushed beyond its intended limits.

III *Climate and Physical Environment*

1 ✱ TEMPERATURE: HUMAN HEAT AND ANIMAL HEAT

I

Effect of Heat on the Living Cell : Warm-blooded Animals and Animals with Varying Temperature : Artificial Fevers : Physical and Chemical Heat Regulation : Thermal Neutrality

Even children notice that the activity of the lower living beings varies with the seasons, and biologists learnedly explain that the speed of the physico-chemical reactions upon which life depends increases with the temperature of the living cell. Greatly slowed by the cold, vital activity reaches its maximum at about 104° F. but when the temperature of the cell passes 113° F. its very existence is in peril. In a word, cold preserves life by slowing it up. Excessive heat kills.

These thermal influences explain the influence of climate on the activity of many animals. Most living creatures, in fact, approach the temperature of their surroundings and their vital actions depend upon this fact. Thus insects and cold-blooded animals—poikilotherms, in scientific language—appear only during the fine seasons in temperate climes and lead a slow-motion life when the outside temperature is low.

The first living creatures were all like that, but in the course of evolution organisms developed which were capable of maintaining their own temperature at a fairly constant level of 95° to 104° F. These warm-blooded animals—or homoiotherms—are always in favorable conditions and soon show their superiority over the other living creatures.

For a long time people believed improperly that the constant temperature of warm-blooded animals removed them from the thermal influence of their surroundings. This independence is only apparent, for the animal cannot maintain this constant temperature unless he can compensate for his thermal losses, and the variation of this essential compensation causes perpetual excitation.

It was not until the end of the nineteenth century that physiologists realized the importance of this heat regulation in man. Albert Dastre was the first to proclaim: "Animal heat is not just any chapter in the history of life. It is the principal chapter, standing at the crossroads of biology." More philosophically, Claude Bernard defined life as "a conflict between an organism and the external environment."

There are nevertheless pauses in the conflict. Under certain conditions the balance between man and his surroundings requires no effort and the respite is accompanied by a feeling of great well-being. At that time man is at his physiological best, more productive, his mind more active, as if the organism, freed from its constant struggle against environment, could transfer all its energy to other activities.

But all superiority has its weaknesses. By its very constitution no homoiotherm—and man in particular—can let his thermal production lapse as can the cold-blooded animals. Even during the most complete repose man's heat must not drop below a minimum. This production of heat in repose—basal metabolism—is a heavy load to carry since the organism must produce a minimum of energy, even at rest, equal to that required for moderate effort. The human body is in a way like a

boiler always kept under pressure, even when no steam is needed.

For from the mechanical point of view a living creature is like a steam engine. Potential energy furnished by foodstuffs and liberated by their slow combustion generates physiological energy, which in turn is transformed into mechanical energy when the body is at work. The surplus is dissipated in thermal energy, the origin of animal heat. In cold-blooded creatures this animal heat raises the temperature of the body slightly above that of its surroundings, but in homoiotherms it must maintain a constant internal temperature. So the body heat in warm-blooded animals must be produced on a variable basis capable of adaptation to an interchange between the animal and its environment.

Here is a disturbing fact: the internal temperature of such primitive mammals as the *Ornithorhynchus* (the duckbill platypus) and the echidna (an egg-laying mammal, the spiny anteater of Australia) never rises above about 86° F. Is this because they may be the link between cold-blooded animals and the higher warm-blooded mammals whose normal temperature range is from 98.6° to 102.2° F.? Birds are warmer blooded than mammals, with a body temperature of 105.8° F.

Although relatively constant, the internal temperature of homoiotherms is subject to very important deviations. Not only do temperature variations cause physiological change because of different cell activity, but in case of infection the strength relationship between germ and terrain is also changed. Fever multiplies the defenses of the organism, so sometimes medicine will induce it artificially to fight certain diseases. It is particularly efficacious in the case of microbes which succumb to heat at 104° F. No positive therapeutic result has as yet been obtained at the opposite end of the thermometer.

We know that the body will not stand internal temperatures higher than about 109° F. but we do not know how far we can go by chilling. In cancer research recent experiments have

lowered the body temperature of patients to about 73° F. without ill effects. Vital activity decreases with the temperature so the body undergoes less wear and tear as the thermometer drops. Some imaginative science-fiction writers have written about keeping men alive for centuries by lowering their body temperature artificially, as nature does for poikilotherms.

For homoiotherms nature has another routine. The human body normally reacts to oppose any reduction of internal temperature. When the surroundings grow colder, the organism reacts by first reducing the peripheral circulation through contracting the blood vessels. When this vaso-constriction is not enough, the body bristles whatever hair is left, a memento of its furry animal origins. And as this childish reflex has become inefficacious, since man is no longer fur-bearing, there is nothing left but to step up the rate of internal heat production. When the outside cold becomes so severe that the body can no longer generate compensating heat, the ultimate result is death.

Conversely, when the environment grows too hot, the body heat has a tendency to climb also until the body can get its defense mechanisms into action. The opposite of vaso-constriction, the superficial blood vessels are dilated and so diminish the thermal resistance of the skin. If this vaso-dilation is insufficient, the next step is perspiration: evaporation of sweat from the skin carries off from the body the latent heat of vaporization.

All warm-blooded creatures can be divided into two categories on the basis of heat-regulating mechanism. The first group possesses sudorific glands, like man, horses and cows. The second has none—and includes dogs and most carnivorous animals. The first regulates its heat by evaporation from the skin. The second can give off water vapor only from their mucous surfaces. This is accomplished by increasing the mucous area exposed and speeding up its contact with the air—which is why a dog, when hot, goes around panting with his tongue hanging out.

When the surroundings continue to grow hotter and hotter, the balance is destroyed, the internal heat rises, cell activity increases and death follows from heat stroke.

The feeling of well-being which accompanies a respite in the thermal struggle between man and his environment is much more marked when the body is in repose. This balance between body heat and the heat of the surroundings is called by physiologists "thermic neutrality." The comfort point is obviously increasingly lower as the body is increasingly active, inasmuch as activity produces heat. In a normally dressed man in repose the comfort point is from 64° to 68° F., but if he is doing tiring physical work it drops to 46.4° F. A naked man in repose will be thermically neutral at 78.8° F.

Recent research has underlined the importance of these points of thermic neutrality, since they determine the maximum efficiency of the human machine.

It is not surprising that the thermic neutrality of most warm-blooded animals is close to the mean temperature for the latitude in which they live. Whether this phenomenon be attributed to adaptation by Lamarckists or to selection by Darwinists, there is no doubt that it is an extremely favorable adjustment. We are speaking, of course, of normal activity, for the thermic neutrality of a swallow in repose is 82.4° F. and in flight 59° to 68° F.

In any case it would seem at first glance that man's thermic neutrality is normally higher than the mean temperature of temperate climates. This latter is usually considered to be the fairly constant soil temperature at a depth of eighteen to twenty feet, or 53° to 55° F., while man normally considers temperature around 65° F. as comfortable. This point is difficult to fix exactly because of the artificial aspects of modern life, from clothing to activity, which for most men is less than his normal needs. We have every reason to believe that if man had to seek his own food directly and struggle for existence against other animals, his neutral temperature would be around 55° F., which suggests the appearance of mankind

in a temperate clime, or even slightly warmer if his pilose protection were no more efficacious than it is today.

Warm-blooded animals instinctively seek thermic neutrality. This fact probably explains the nocturnal activity of rodents and herbivorous animals, for nights are cooler than days and closer to the comfort point of these animals. Moreover, as their neutrality temperature is higher in the daytime because of their reduced activity, they are in better thermic balance than diurnal animals, which must have much better thermic defense than the nocturnal ones. This defense is obtained by birds, for instance, by curling up to reduce the surface of heat loss or heat gain and by achieving heat insulation by the several layers of air imprisoned in their feathers.

Probably man was originally nocturnal, like the other herbivorous and fructivorous animals. The discovery of fire must have liberated him from his thermic subjection and he has consequently lost the keenness of certain faculties, particularly that of sight—to the extent that such deficiencies are hereditary, which is not at all certain.

II

Sensation of Warmth : Thermic Equations and Resultant Temperatures

The work of Newton linked the exchange of heat with the concept of temperature. Superficial scientists have tried to show relation between the sensation of warmth induced by an environment or an object and its actual temperature. Nothing could be less true, for it is impossible for the human body to judge temperature by the sense of touch. The body can only register a variation in the loss of heat. Now this transmission of heat is a function not only of the difference in temperature between the skin and the foreign object but also of the coefficient of mutual transmission, which depends upon the na-

ture and physical characteristics of the fluid or solid placed in contact with the skin. At the same temperature of 65° F. iron feels cold but wood feels warm. This is because iron, an excellent conductor of heat, instantly absorbs much superficial heat from the skin, while wood, a poor conductor, is warmed only on the surface. Likewise, water at 68° F. feels colder than air at 32° F.

Like all warm and humid objects, the human body loses heat by conduction, convection, radiation, and evaporation. Conduction depends upon the nature and the temperature of the objects with which the body comes into direct contact. Convection is a special case of conduction and results from the warming of the air in contact with the skin, depending upon the temperature of the air and the rate of its circulation. Radiation depends upon the temperature and nature of the walls of the enclosure. Evaporation depends upon the humidity and rate of circulation of the air.

To sum up: total exchange of heat between the human body and its surroundings depends upon the temperature and nature of surrounding objects; on the temperature of the walls of the enclosure; on the temperature, humidity and circulation rate of the air.

Experience has shown that the sensations of heat or cold are linked to the aggregate heat losses of the human body. The sensation of heat, in a given environment, does not therefore depend alone upon the air temperature as registered by the ordinary thermometer. True, this factor is an important one: It is all the more so when, as is often the case, the air is stagnant and the walls of the enclosure as well as objects in contact with the human body are at almost identical temperatures with the air. But this is not always the case. Furthermore, when the surroundings become increasingly warm, perspiration takes on added importance, and the humidity of the air becomes a factor impossible to ignore.

Under different conditions, even when the air temperature is not the same, it may *feel* the same. These conditions are said

to be "thermally equivalent." Experiments performed with humans over a period of years recently have shown us how to measure these equivalents with some precision. First we must distinguish between transitional equivalents and stationary equivalents, for the skin and hair are hydroscopic in varying degrees—that is to say, their power of absorbing moisture is not always the same. Therefore transition from one atmosphere to another of different humidity will produce either an absorption or emission of water vapor from the skin and hairs, which will upset the heat exchange as such.

Let us say that the temperature of the air and the walls of a given enclosure is 77° F., that the relative humidity is 20%, and the air is circulating with a speed of six feet a second. The sensation of warmth would be the same to the human body as if the temperature of the air and walls were 68° F., the humidity 100%, and the air stationary.

The sensation of heat produced by any given surroundings is governed by the resultant temperature based on the following thermal factors: temperature, humidity and rate of circulation of the air, and the temperature of the walls. The concept of thermally equivalent surroundings in which the thermal factors may vary, and yet produce equal sensations of heat to the body, is particularly useful in comparing outside environments taking into account solar radiation and the speed to the wind. It is equally essential in determining exact thermal conditions in radiant heating or in deep mines, where the walls are warmer than the air.

To sum up, the ordinary dry-bulb thermometer is no better guide to the feeling of heat than a man's height is an index to his weight. The feeling of heat is a complex of resultant temperatures depending upon all significant factors influencing the loss of heat of the human body.

2 ✳ OTHER CLIMATIC FACTORS

I

Humidity : Atmospheric Pressure : Wind

Although the sensation of heat is an essential climatic factor, it is obviously not the only one that has influence on human life.

Aside from its thermal action, humidity plays a big part in the transmission of contagious diseases. The virulence of disease germs is increased by a very humid atmosphere and attenuated by dry air. The microbic particles enter the organism more easily when surrounded by an aqueous film.

Atmospheric humidity also affects respiration. Heat produced by exothermic reaction in the lungs is normally carried off by the air exhaled. The heat is absorbed less readily by humid air, which explains why deep breathing is aided by dry, cool air.

Although rain increases humidity, it also has the happy effect of cleansing the atmosphere. Just as the vapor rising from heated culture media is sterile, so the condensed vapor that falls as rain contains no bacteria. The same is not true of

fog and mist. When the wind whips the surface of open water, it apparently skims off tiny drops containing indigenous microbes. Fogs are equally dangerous as carriers of toxic gases absorbed in industrial areas.

The most desirable degree of humidity for dwellings, offices and factories has long been debated. If the air is too dry, the mucous surfaces are irritated and hindered in their role of filtering moist bacteria. And on the other hand, too much humidity increases the virulence of the germs. Study has determined that relative humidity between 50% and 60% is about right for the inside of buildings at temperatures between 59° F. and 68° F. In the absence of artificial humidity control, a balance is achieved between vapor pressure inside and outside of buildings. So in winter the air inside of heated buildings may be very dry, while air outside is humid. Perhaps this explains why, contrary to popular belief, mortality rates are higher in cold, dry weather than in cold, damp weather. Dry air seems to be more harmful than humid air.

Since internal pressures in the human body depend upon atmospheric pressure, barometric changes cause modification in internal exchanges. When atmospheric pressure is low, the amount of oxygen in the blood stream is decreased, and in compensation the circulation must be increased. This causes an increased pulse rate. The extra strain on the heart is more considerable when the body is hard at work, a fact which explains why mountain sickness is more common among Alpinists than among airmen. Decrease of oxygen also increases the output of the lungs.

Physiologists have recently called attention to the probable influence of pressure variations on the secretions of the endocrine glands through changes in the rhythm of osmosis. Men live more intensely at lower atmospheric pressure, according to Huntington, whose American experiments on the relationship of activity to weather seem to bear out this theory statistically.

Wind is a decisive factor of climate. In temperate regions

especially each shift in the wind is followed by a more or less radical change in the weather. Since the direction from which it blows determines the nature of the changes it brings, the wind influences human life most in regions surrounded by adjacent areas with different climates. In the Arctic regions, where the same climate serves vast areas, the wind plays a secondary role. In the temperate zones, on the contrary, particularly in North America and Western Europe, wind is a prime climatological factor.

Wind is of course an important element in determining heat sensation in humans, its physiological importance varying with the seasons. In very cold winter temperatures, the wind lowers the resistance of the system, while in summer it increases human resistance. Mortality statistics, particularly those of Huntington based on the areas of New York, Chicago, Washington, and St. Louis, definitely confirm that wind increases the death rate when the temperature goes down too far and decreases it in the hot summer weather.

Illnesses of varying degrees of gravity often follow winds that are outside the usual pattern of climate. The classic example is that of the sirocco, a hot, dry, North African wind which raises the temperature, day and night alike, to around 104° F. It induces dehydration and a rise in internal temperature—particularly among children—a condition which is sometimes fatal.

It has long been recognized that wind has a very strong effect on states of mind. As long ago as the beginning of the eighteenth century Voltaire remarked that when the wind blew from the east, the number of suicides in London increased considerably, a fact which caused no surprise because everyone else was low in spirits, too. Voltaire himself noted that he, too, was so depressed he could no longer laugh. It was during an east wind that Charles I was decapitated and James II dethroned.

Huntington reports that the "Wind of the 122 Days" which blows from the north in eastern Iran irritates the tempers

of Europeans and Persians alike, destroying all energy and initiative.

Undomesticated animals are perhaps more sensitive to the wind than is man. They hide when the wind reaches a certain violence and all of them, even the fishes despite their protective element, completely modify their behavior according to the direction of the wind.

We know almost nothing of the mechanics of these psychic reactions. There are some who blame the changes on variations in the earth's magnetic field, but this is merely substituting one enigma for another, and adds up to nothing more than words.

II

Solar and Terrestrial Radiation : The Thorny Question of the Possible Biological Influence of the Earth's Magnetic Field

Solar radiation, essentially thermal, is the work of invisible infrared rays. It has little influence on the body except for the sensation of warmth. Two other factors in solar radiation, however, are usually recognized by physiologists as important: the extremely short ultraviolet rays, invisible but with important biological properties, notably germicidal; and the visible light rays, ranging from red to purple when broken down into the spectrum.

As measured in a rural area and striking an average over the whole year, solar energy undergoes the following partition on striking the earth's stratosphere: 40% is reflected back into space without advantage to the earth; 17% is absorbed by the atmosphere; and 43% reaches the earth's surface. The last figure is reduced in some regions by impure atmosphere. It is from 10% to 30% less in smoky industrial cities and all wave lengths are affected, so humans are affected not only by the lessening of germicidal blue and ultraviolet rays, but by a decrease in Vitamin D formation and a slowing up in the

metabolism of minerals, both dependent upon solar radiation.

Repeated and prolonged exposure to the sun's rays causes changes in the superficial circulatory system. The capillaries increase in number and diameter and acquire a continuing aptitude for vaso-dilatation. Cures accomplished by heliotherapy indicate that solar radiation alone makes for the strengthening and development of the muscles. Some esthetes see in it the explanation of the beauty of the ancient Greeks.

The process of adaptation establishes a balance between solar radiation and the permeability of the human epidermis, permeability which is subject to racial variation. For instance, in Memphis, Tennessee, eighty-seven of one hundred Negro children examined showed traces of rickets, and thirty-five of them had characteristic lesions. In New York, rickets (which is treated by solar therapy) is more common among children of Italian immigrants than those of Scandinavian origin.

If natural therapy by solar radiation may be beneficial and has become fashionable in recent years, it is also true that haphazard administration may cause organic disorders aggravated by photosensitivity due to diet or drugs. The over-all balance sheet of the unmethodical practice of nudism seems to be positive, but how many women have compromised their health by overexposure to the sun after anointing themselves with some lotion increasing the photosensitivity of the skin!

True, there has been much research into the possible influence on man of the earth's magnetic and electrostatic fields these past few years. Some has even been really scientific in spirit. Some, on the other hand, has been no more than superficial observation by a family doctor, and the conclusions have been hardly convincing.

Let us recall that differences in electrical potential exist between various parts of the earth's atmosphere. As the earth is a conductor, its periphery constitutes one contour surface of the electric field, the other being materially parallel when the relief is not too broken in cross section. In mountainous regions the contour surfaces tend to parallel the mean of the

terrain. They are therefore further apart in the valleys than on the slopes and the electric field is lower in the hollows than on the peaks. As a rule the earth acts as a negatively charged conductor. The atmosphere is positively charged. In any event, the direction and strength of a field at a given moment vary greatly from place to place.

The field is generally pointed earthward in the open country and is conventionally given the positive symbol. In the cities and forests it is practically nil, for the same reason as in the deep valleys. In caves and in certain rocks it is negative—meaning it is directed skyward.

It is generally admitted in biology that every act of nutrition or movement generates electricity and that exchanges on all levels are thus quantitatively dependent upon the intensity of the electrical phenomena we have been discussing. Recent studies seem to indicate that the growth of plants and animals varies to a large measure according to whether they are stato-electrically insulated or make electrical contact with the soil. It would seem that insulated organisms grow much more than others. Some physiologists maintain that many plants and animals will develop only in certain fields.

Men living in an electropositive field, according to this theory, are more immune to tuberculosis and cancer than those living in a neutral field, and it has been observed that those living in negative-field valleys are quickly dying out. Ernst Pech concluded, from his own observations, that the human species can colonize successfully, suitably and for an indefinite period, only in an atmosphere carrying a strong positive charge.

Other physiologists have studied the effect on animals of artificial ionization of the air. The ionization seems to produce a temporary state of general stimulation, followed by a decline in normal activity. But we may properly wonder if this phenomenon is due exclusively to ionization or if the ozone and nitrogenous oxides which are by-products of an electrical discharge might not be also involved.

The question of electrical influences is one of the most complex of all bioclimatic problems. Few experiments have been performed in which other factors have not been eliminated. As for observation of human groups, they are subject to the classic objections: do the experimental subjects have the same heredity and eat the same food? Otherwise it would be difficult to rule out influences other than those of electricity.

III

Air and Health : Anthropotoxins and the Carbonic Gases : Ventilation : Priority of the Thermal Factor over the Chemical

Must we evoke the now outmoded ghosts of anthropotoxin and the dangers of low-percentage carbonic acid gas? The so-called human poison once supposed to be emitted by the lungs in closed confines has never existed except in the minds of a few physiologists. As for carbon dioxide, it must reach a level of 30% in the air in order to cause asphyxia. In weak doses, on the contrary, it stimulates respiration and is used therapeutically in conjunction with oxygen to revive victims of drowning.

It remains nevertheless true that the human organism has a natural repulsion for air vitiated by the by-products of life which give that characteristic animal odor to closed spaces. The exact composition of these offensive-smelling substances, incidentally, is not well known. In addition to ammonia and the fatty amins, they contain the constituent elements of the human cell—carbonic acid, hydrogen, phosphorus and sulphur. Their physiological action is even more mysterious. It would seem that they diminish the appetite in children and react unfavorably on their growth. Young animals, too, show retarded growth when raised in malodorous atmosphere as compared to those raised in pure air. Appetite, measured in

amount of food consumed, is diminished by 10%, and growth measured by weight is diminished by the same percentage. However, systematic long-term experimental comparisons do not exist and we may well wonder if the differences noted are not due to experimental error.

It has been indeed proved that air-borne contagion is increased by the impurity of the atmosphere, and the old theory of miasmas—by which the origin and spread of epidemics was laid to impurities in the air—was not completely without foundation. According to Auguste Trillat, the putrid elements provide nourishment for microbes and permit them to multiply.

We have the question of whether it would be desirable to rid the air of all micro-organisms, or whether some are not indispensable to the life of warm-blooded animals. Although some vertebrates are completely aseptic, Pasteur leaned toward an affirmative answer to the latter part of the question. In leaving the final answer to his disciples, Pasteur pointed out that bacteria were present in considerable numbers and varieties in almost all vertebrates, particularly domesticated animals.

The experiments of Cohendy, on the other hand, lead to a negative conclusion. Chickens raised in conditions made as completely aseptic as possible developed normally, and at autopsy showed no trace of bacteria. And yet they weighed slightly less than chickens raised in normal conditions, although they ate more. So we may assume that while the presence of bacteria is not essential to life, it helps the body make full use of food.

Independently of its pollution by by-products of animal life, the air often is vitiated by the products of industry and combustion. The most harmful of industrial gases is carbon monoxide, generated either by industrial heating or by power plants or by automobile engines. Even at percentages much lower than the fatal dose, carbon monoxide may cause a slowing action, the consequences of which are not fully known. It is true that,

like all poisons, it may be a stimulant in very small doses, thus adding to the general excitation characteristic of city life.

Be that as it may, experiments have shown that the introduction into a room of forty to forty-five cubic meters of fresh air per person per hour will abolish all bad smells of human origin.

Research in air conditioning has emphasized the importance of the temperature of air that man breathes. In conditions of thermal equivalence, men are much more apt to be active when they breathe air of about 55° F. than of about 65° F. This indicates the advantage of radiant heating, in which the walls are warmer than the air. Gilquin in France explains this action by the exothermic (heat-releasing) character of lung activity, automatically reduced when the cooling power of the air is diminished.

All the above tends to confirm the fact that the action of climate upon the human body is more thermal than chemical.

3 * EFFECT OF CLIMATE ON MORTALITY, FERTILITY AND EFFICIENCY

I

Seasonal Variations in Deaths and Conceptions : Summer and Winter Diseases : Influence of Temperature, Humidity and Barometric Pressure on Mortality

Hippocrates, who is the father—if not the god—of medicine and whose genius should evoke humility in the modern physician, had already noted the influence of climate and the weather upon health and wrote about it at great length. It is astonishing that the question has never been the object of really scientific research. It is only since the beginning of the twentieth century that we have any statistics at all reliable.

Among peoples who have remained close to nature, the mortality rate is lowest when the average daily temperature corresponds to thermal neutrality—about 63° F. Remarkably enough, the number of conceptions is highest under the same conditions. In those countries, therefore, where artificial heating and cooling have not yet altered the natural rhythm of existence, the growth of population reckoned from the point of conception reaches a marked peak at this period most favora-

ble for life. Huntington's statistics on the death rate and conceptions in Japan from 1901 to 1910 illustrate clearly these seasonal variations (*figure 4*).

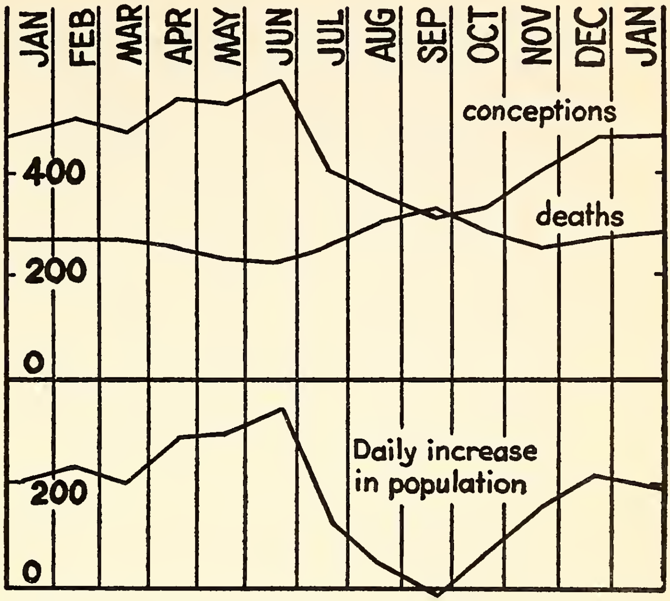

Fig. 4: *Seasonal variations of conception and death in Japan, averaged for the years 1901-1910. (According to Ellsworth Huntington.)*

Obviously these seasonal differences would be diminished in more-civilized countries where man has tampered with the natural climate and natural nourishment. "Civilized man," according to the popular saying, "is an animal which drinks wine and copulates all year around." So the conception rate tends to be spread evenly throughout the year in civilized communities.

Variations in the death rate are also seasonal in all but the most modern countries. Statistics by Charles Winslow and L. P. Herrington (*figure 5*) show that in 1900 there were marked peaks and valleys in the death rate in the United States. The 1940 mortality curve for the United States is not

only generally lower but shows much less difference between maximum and minimum.

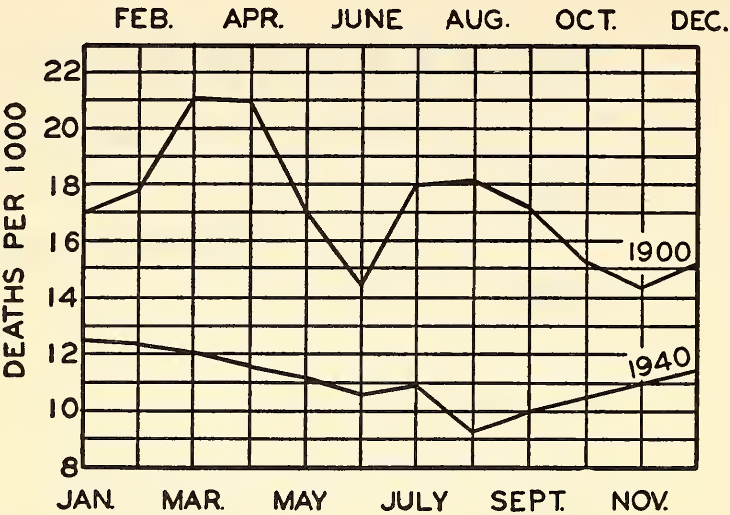

Fig. 5: *Monthly death rate from all causes in the United States for 1900 and 1940. (From* Temperature and Human Life *by Charles Winslow and L. P. Herrington.)*

The annual rhythm of mortality may be largely explained by the seasonal character of most diseases caused by microbes. There are, in fact, diseases specific to cold countries and to hot countries. In temperate climes the latter reach their height in the summer months and the former toward the end of winter. Thus malaria, yellow fever, bubonic plague, typhoid fever, and cholera are more frequent in hot weather, while diphtheria, measles, scarlet fever, pneumonia and typhus are cold-weather diseases.

For some years now hygienists have been methodically studying seasonal variations in disease and plotting frequency curves. Woringer has demonstrated, for instance, that in temperate climates the curve is sinusoidal, with a single peak and a single valley per year (*figure 6*). The seasonal differences are

much less in approaching the equator, where the climate is more even the year around. Curves for both hemispheres are similar except that they are six months apart.

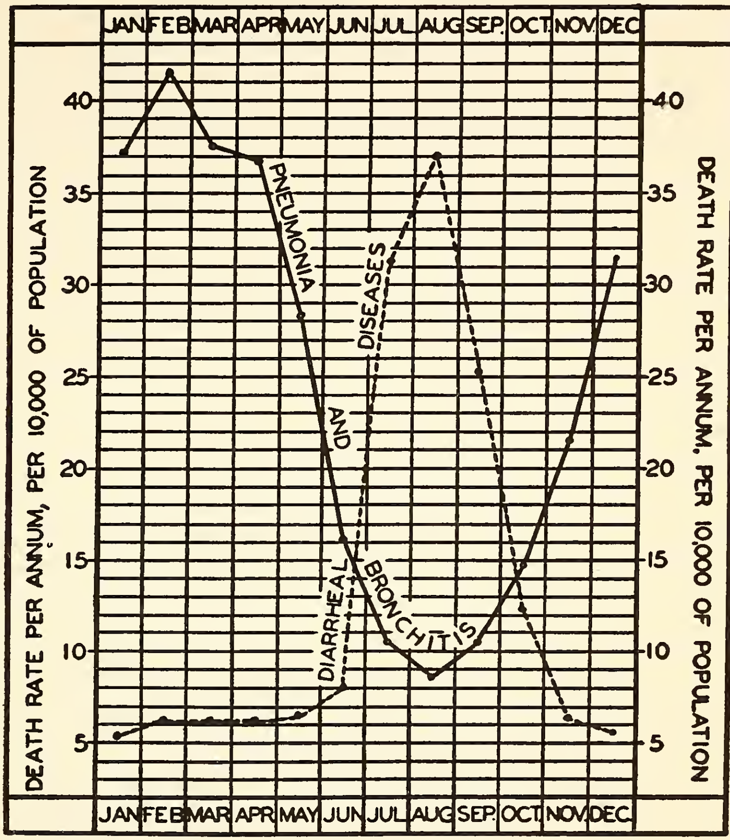

Fig. 6: *Seasonal change in death rates from respiratory diseases compared to that from diseases of the intestinal tract. (Report of the Department of Health, Chicago, adapted by Winslow and Herringon in* Temperature and Human Life.)

It would be oversimplification to attribute these variations *a priori* to temperature changes alone. Although Van Loghem in Holland has shown a close relationship between the rise of

respiratory ailments and the drop in temperature, we must not forget the seasonal variations of the vitamin content of food-stuffs, which has a great influence on resistance of the body.

Biologists and statisticians have also tried to show a direct relationship between mortality rates and temperature, humidity and barometric pressure. Huntington's method consists in plotting a graph of death rates in which the ordinates are the temperatures and the abscissas another climatic factor—humidity, for example. In 1949, the author combined the Huntington statistics for southern France with those of Duon and LaCroix for the Parisian region and plotted a mortality graph in terms of temperature and humidity. The curves showed, for instance, that the death rate at 50° F. with the humidity at 45% is the same as that for 33.8° F. with the humidity at 80%—a figure about 20% higher than the average mortality rate for France of 28.5 per thousand.

The death rate is clearly lower in warm weather than in cold. But contrary to popular belief deaths are more frequent in winter in dry weather than in humid. Thus at 41° F. the mortality rate drops 20% when the humidity rises from 45% to 80%. This conclusion is confirmed by the work of Huntington and other scientists.

Relative humidity inside buildings is of course decreased by winter heating. Thus saturated outside air (100%) at freezing will drop to 30% when brought inside by natural ventilation and heated to 64° F., which explains the need for humidifying inside air in steam-heated premises. On the other hand, when the temperature rises to about 68° F. higher humidity means higher mortality. So the relative humidity inside heated quarters should be maintained somewhere between 50% and 60%.

We have also plotted the mortality rate in the Parisian region in terms of temperature and barometric pressure. Between the temperatures of 54° F. and 63° F. it would seem to be measurably independent of barometric pressure. Below this range the optimum of pressure is 29.91 inches of mercury. Mortality is considerably higher at the same temperature when

the barometer reading is above or below this figure. However, although these figures are based on study of a large number of subjects, they need to be checked by the work of other men. The graph shows that mortality at 41° F. with pressure at 29.33 inches is the same as that at 23° F. with the barometer at 30.31 inches—a point 34% above the average death rate for the Paris region.

It is certainly possible, if not probable, that these climatic factors are more important by their variations than by their absolute value. Huntington points out, for instance, that a drop in temperature from one day to the next causes a drop in mortality rates.

The influence of pressure changes is too uncertain to provide conclusions. On the other hand, it is quite clear that a drop in temperature almost always brings a drop in the death rate, regardless of humidity or barometric pressure. In any case, the death rate shows a decline when the relative humidity also falls. Conversely, higher temperature almost always brings higher mortality. Likewise a decrease in relative humidity, other factors being equal, lowers the death rate.

Are these facts due to the general law of physiology that a variation may be injurious when it is great but favorable and stimulating when minimal?

To sum up, we find that below a temperature of 65° F., all other factors being equal, the mortality decreases with the rise in temperature and relative humidity. But mortality drops suddenly, and temporarily, if temperature and relative humidity fall. This phenomenon may be synthetized as follows: when the temperature or the humidity fall, there is an immediate stimulating effect on man which decreases his mortality. Then, if the temperature and the humidity remain constant, the mortality rate rises to adjust itself to the normal for a given temperature.

Are these phenomena due to the direct action of temperature and humidity? Actually, the arrival of a tropical air mass with its accompanying rise in temperature and humidity may

well exercise its depressing effects by other factors at present unknown. Similarly the Arctic air masses bringing low temperatures and humidity also bring other meteorological variations which may be the real origin of increased efficacy of the human defense mechanisms.

Work in this field has to date been little more than a series of rough sketches, yet it seems to open to biologists and statisticians an area of research of considerable scope.

II

Decrease in Work Capacity Due to Heat : Efficiency at Thermal Neutrality : Influence of Temperature on Manual Skill and Accident Frequency

The influence of temperature on physical activity, and therefore on work yield, is much more apparent than its influence on health. The surprising fact is that it has only been studied systematically since 1925. There seem to be many reasons.

First, the initial scientific study of the biological effect of climatic factors began only about a generation ago. Second, earlier observations on the efficiency of physical work seem incoherent at high temperatures because the heat of the environment was measured only by the ordinary dry-bulb thermometer. Inasmuch as the body, particularly at work, emits more heat at high temperatures by evaporation than by radiation and convection, the humidity factor must be considered in evaluating the environment; in other words, by the resultant temperature. Furthermore, consideration must be given to the differentiation of men on both sides of the mean—in other words, a large number of subjects must be studied.

Roughly speaking, all previous research has shown that the efficiency of physical work is at a maximum at the temperature of thermal neutrality, that is to say, under conditions of

maximum comfort for the given activity. Let us recall that the temperature of thermal neutrality is lower when the required energy increases or when clothing is warmer.

When temperature rises progressively, the human body must reduce its activity in the ratio of the amount of heat it is able to return to the surroundings. This explanation obviously applies only to physical work. What, then, happens physiologically? Giblin suggests that vaso-dilatation, which brings blood to the surface, diminishes muscular circulation and thereby reduces physical activity. It is quite clear that intellectual activity is less affected by an abnormal rise in temperature.

The efficiency of manual labor in relation to ambient heat has been studied from two different angles. The first method consists in exacting heavy, strenuous labor from the workers at a fixed rhythm, and of determining the elapsed time before fatigue forces them to stop. This is obviously an inexact method because of the subjective nature of fatigue. However, English studies have shown that production varies in the proportion of 6 to 1 when the resultant temperature is raised from 59° F. to about 113° F.

As a rule, however, the problem is not studied in this manner. It is especially important to learn the variations in efficiency of workers employed at a continuous job from six to eight hours a day. So a second method has been evolved, which studies workers at their normal tasks, engaged in real production under different thermal conditions. The production may be determined either statistically or analytically by putting the subjects to work in a laboratory, the climatic conditions of which can be varied artificially. The first studies by this method were made in mines, where the underground temperature increases proportionately with the depth.

Roughly, a miner's efficiency diminishes by half between thermal neutrality, about 64° F., and a temperature of about 83° F. It is diminished by half again when the temperature rises by another five to six degrees Fahrenheit. The decrease is slow at first but accelerates rapidly as the temperature rises.

It is worth noting that there are considerable data regarding work in very hot surroundings, but almost nothing about work in the cold. Whether this is because cold does not lower efficiency as much as heat, or because cold is more easily corrected than extreme heat, we do not know.

The work of Huntington indicates that a maximum work yield is achieved only when the temperature does not remain too constant at its optimum. Slight variations about the mean seem to be necessary. According to this author, work in factories reaches its maximum at that season of the year when the average temperature varies five to seven degrees from day to day. Production is greater during falling temperatures than during a rise. Actually, there seems to be no systematic research that would back up this conclusion. But there is no doubt that variations are stimulating in all fields, including that of labor.

It would be oversimplification, however, to attribute reduced labor efficiency exclusively to metabolism changes due to physical work. Abnormally hot or cold surroundings do diminish a worker's skill and mental alertness, which in turn causes a qualitative and quantitative decrease in production, even in tasks requiring very little energy expenditure. For the same reason, accidents decline sharply in the neighborhood of thermal neutrality. A classic example of this point is the record of the Morro Velho, a Brazilian mine, which reduced fatal accidents from twenty to six in a comparative sixteen-month period following the installation of a cooling system which lowered the temperature from 88° F. to 82° F. We might wish to see statistics over a much longer period, but other methodical observations confirm this conclusion.

Little valid research has been done into the variations of efficiency of mental work, although it does appear to be much less affected by surrounding temperatures, probably because no appreciable increase in metabolism seems to be involved. Although some current studies indicate that the mind grows somewhat sluggish at very high or very low temperatures,

American researchers have found little variation in mental activity between 41° F. and 77° F., provided the subjects are appropriately clothed. It would seem that there is indeed a mental optimum at thermal neutrality, but it is much less marked than for physical work. Moreover, more complete large-scale research is needed.

The concept of comfort does seem to have sound physiological basis. It is somewhat childish to suppose that laziness alone leads homoiotherms—men and animals alike—to seek out the most agreeable climatic conditions. This instinct stems from the natural law of conservation of strength.

III

Disease and Mortality among Workers in Terms of Climate : Outdoor Yards, Mines and Steel Mills : Need for Suitable Regulation

Diseases called *à frigore* are rather diseases of chilling than of cold. They are caused by a sudden imbalance between insufficient heat production and excessive heat loss by the body. Winter is, of course, favorable to such diseases but they may also appear in summer if a perspiring body is abruptly subjected to intense chilling, either by a drop in temperature or a shift in the wind.

From this viewpoint work environment may be divided into three categories: those in which the temperature is abnormally low, such as outdoor work yards; those in which the temperature is abnormally high, such as boiler rooms; and those in which the ambient heat is subject to frequent variations.

Statistics show, for instance, that dock workers suffer twice the death rate from respiratory ailments that indoor workers do. For the over-all classification of outdoor workers—peddlers, hawkers, carpenters, and such—the mortality rate is 70% higher than for the same workers with indoor jobs. We must, of

course, take into account the general health level of these workers, whose diet is sometimes deficient. Yet their mortality from diseases in which chilling plays no part is only 21% higher than the average, which indicates the importance of the thermal factor.

Workers in abnormally hot conditions obviously suffer acute effects of heat. But serious accidents, such as heat stroke, tend to eliminate all but those able to stand high temperatures. When high temperatures are accompanied by high humidity, we find an increase of respiratory ailments. Those cotton spinners and weavers who work in a hot, damp atmosphere have a death rate two or three times as high as wool workers with similar jobs but in normal conditions of heat and humidity. The mines offer us the most interesting field of investigation. According to the excellent statistics of Vernon and Bedford, time lost through sickness in coal mines varies strictly with the temperature. Examination of twenty-three thousand men from ten collieries shows that time lost rises regularly by 63% whenever the temperature rises from 68° F. to 79° F. Similarly, the mortality rate is increased by 50% when the temperature rises from 66° F. to 79° F.

In factories and mills subject to frequent changes in temperature, disease and mortality rates are higher when the work is more strenuous. In iron and steel mills, workers exposed to radiant heat and big temperature changes are three times more subject to pneumonia than their fellow workers in more uniform thermal conditions. And yet these are generally well-paid and well-fed workers, whose general state of health is indicated by the fact that their death rate is lower than the average level of all workingmen. On the other hand, death from respiratory ailments is from two to three times more frequent among founders, puddlers, and rolling-mill workers than among their fellows.

These observations, particularly those relative to mines, throw light on the mortality statistics of previous chapters. It would seem that it is ambient heat which has a direct influ-

ence on disease and mortality, and not the other climatic factors which accompany temperature changes.

Thus the balance sheet of abnormal conditions, particularly excessive heat in places of work, may be translated in terms of a diminished labor yield, an increase in disease and mortality rates, and thus social debits and a net loss of human capital, outside of any sentimental considerations.

These conclusions are obviously not new. The repugnance of workers for very hot surroundings is as old as the world, and has led to some governments taking action in the past century. But such legislation, largely outdated in most countries, displays a general ignorance of the question.

German law, for instance, forbids miners to work in a dry temperature of more than 28° C. (82.4° F.). And yet 29° C. (84.2° F.) with a slight circulation of the dry air is much more bearable than 24° C. (75.2° F.) with the air static and humid. French laws forbid underground work at more than 35° C. dry-bulb thermometer or 30° C. wet-bulb (95° F. and 86° F.), thus taking humidity into consideration but making no allowance for the movement of the air or the temperature of the walls. British regulations for the textile industry are even stricter, forbidding humidification when wet-bulb temperature passes 75° F. and barring work at more than 78° F., but the law takes no cognizance of air circulation or of dry-bulb temperatures, which must be considered even at high humidity.

These various divergences give some idea of the ineptitude of most attempts to legislate comfort. In most countries the law is interested only in mines and pays no attention to surface industry. In view of the fact that improvement of working climate inevitably pays off in increased productivity and preservation of human capital, the deficiency of regulation is bewildering. An international organization for workers' hygiene is urgently needed to take the matter in hand and help enact universal legislation that would be valid for all countries of the temperate zone, with a few local adjustments in detail.

Since it is undeniably human capital which determines the

success of a business or the prosperity of a country, both material interests and humanitarian anxieties would be jointly served.

Research which we have conducted in France under the auspices of the Bureau of Mines indicates that it would be wise to limit resultant temperature for underground work to 28° C. (82.4° F.), instead of the higher temperatures now legal. And since more or less complete nudity is practical underground but dangerous in surface factories where the opening and closing of doors could cause abrupt thermal changes, it would be wise to limit above-ground industrial temperatures to a still lower figure.

Lacking government regulation, it behooves management, with a moral responsibility for the health of the workers, to take cognizance of these important questions and of the current techniques of artificial climates.

Likewise these conclusions should inspire architects who design factories and engineers who plan production. It is in fact possible to abolish abnormal temperature ranges by proper planning and by improved arrangement of production lines and manufacturing processes, inasmuch as in many factories the excess heat is a by-product of the machinery.

These conclusions should also be considered in determining wages and hours. It is obviously unfair to pay the same scale for piecework done in steamingly hot conditions as in comfortable surroundings. For, aside from the danger to their health, workers in unfavorable surroundings cannot attain the efficiency—and therefore the earnings—of their colleagues working in good climatic conditions.

4 * CLIMATE AND CIVILIZATION

I

Four Forms of Civilization : Industrial, Intellectual, Hygienic, and Moral : Their Criteria

If, as appears from the evidence, some climatic conditions are more favorable than others for man's health, activity, and physiological and intellectual fertility, it must follow that climate plays an important part in the evolution of human social groups. Geographers and scientific writers have long felt the truth of this probability, and in the early part of the present century Huntington and his colleagues tried to establish a link between climate and the level of civilization. But if climate is such a vague term, even when reduced to such fundamentals as temperature and humidity, civilization is even more so.

In assigning different degrees of civilization to the various countries of the world, Huntington and his Areopagus of international arbiters made their judgments on the basis of the twelve following criteria:

1) Degree of initiative.
2) Degree of inventive spirit and the capacity to put forth new ideas.

3) Aptitude for managing enterprises of vast scope in time and space.
4) Ability to control other races.
5) Perfection of educational systems.
6) Development of public hygiene.
7) Level of honesty and morality.
8) Degree of individual self-assurance and self-control.
9) Sense of artistic beauty (including architecture).
10) Sense of literary beauty.
11) Sense of natural beauty.
12) Talent for developing systems of philosophy.

It would be difficult to develop a better definition for American civilization! It is not surprising, therefore, that the highest ratings were accorded the Anglo-Saxon countries, although every judge had a slight tendency to overestimate his own country. For civilization comprises as many nuances as does intelligence, and to Confucius a great American industrialist would probably seem a savage.

Let us analyze this idea a little more thoroughly.

Mechanized or industrial civilization may be fairly well defined by the number of its industries, the percentage of adults employed in factories, the standard of living—even by such oversimplified criteria so dear to Americans as the number of automobiles or radio sets *per capita.* To what extent is this standard of living linked to climatic conditions? It depends, obviously, upon the energy and activity of the population, and consequently upon temperature. Also involved are the fertility of the soil—itself linked to climate—and the mineral riches buried in its earth.

But weighing all considerations, these natural advantages are worth only as much as man can make of them. The unexplored ground of forbidding regions may be even richer than that of lands now humming with industrial activity. The proof is that some regions poor in fuel and minerals nevertheless have a prosperous industrial activity in importing raw materials and re-exporting them as manufactured goods. So it is

actually human worth which determines the industrial prosperity of a country, and we may expect to find a close relationship between an industrial civilization, fruit of man's health and activity, and the climate which molds them.

On the contrary, the intellectual civilization of a region may be judged by the fecundity of its literary and scientific works, the number of its schools, the circulation of the books in its libraries, the organization of its research, and such. There is no doubt whatever that all intellectual civilization is bound to the standard of living. Man cannot study, think, and reflect except as his material needs are assured. And since pure scholars are not direct producers, they can live only on the surplus resources of the working masses. Scientific activity and technical research are evidently the by-products of industrial civilization. It is true that philosophic and artistic activity is generally disinterested, but it nevertheless demands the leisure and freedom of mind which come only with a high level of average life.

Some statisticians also speak of a hygienic civilization, the level of which is determined by the number of doctors and hospital installations, and the soundness of social laws. The classic criterion is the death rate, but this should also be studied in connection with the average age of the population. For example, that of France is relatively high compared to neighboring nations, but this is because France is an old country and not necessarily because public hygiene is deficient. The infant mortality rate is a much better criterion for judging public health, as it reflects the standard of living—health and sanitation costing money.

Perhaps we should also consider a distinct moral civilization, based upon the number of law courts, the percentage of criminals *per capita*, and perhaps even the divorce rate. We might also consider honesty in business, although its relationship to material conditions is less obvious. It is certainly essential to the maintenance of society, but as affluence is corruptive, we may look for a lowering of morality in a rich country

on its decline. Rising morality is rather a criterion of the next evolution of civilization.

In essence, then, the standard of living and infant mortality are excellent criteria of a materialistic civilization. Intellectual and artistic activity, which demand achievement and traditions, mark the age of the civilization. And the level of morality is an index to the rise or the imminent decline of the same civilization.

II

Climatic Energy and Civilization "American Style" : Average National Income and Mortality : Ideal Climate : Distribution of Industry in Europe

Ellsworth Huntington developed the map of climatic stimulation acknowledging that optimum conditions call for an average winter temperature of about 41° F. and an average summer temperature of about 70° F., with relative humidity ranging from 50% to 80%, depending upon whether the weather was cloudy. He also gave some importance to the mean variability of temperature. His map of Europe (*figure 7*) based on the above elements was published in his *Civilization and Climate* around 1920. Careful study would permit us to outline a still-more-favored zone comprising the south of England, the north of France, Belgium, the Netherlands, and West Germany.

Huntington and his international colleagues, rating civilization according to the criteria listed earlier in this chapter, established a map of civilized Europe (*figure 8*) that is quite similar to Sir Clements Markham's maps of Europe according to variations of national income (*figure 9*), according to general mortality figures (*figure 10*), and according to infant mortality (*figure 11*). The maps confirm the logic of preceding

conclusions of relationship between standards of living, health, and materialistic civilization.

Finally, a comparison of the Huntington and Markham maps with Huntington's global maps of climatic stimulation shows a tight relationship between climate and the material and hygienic factors of industrial civilization.

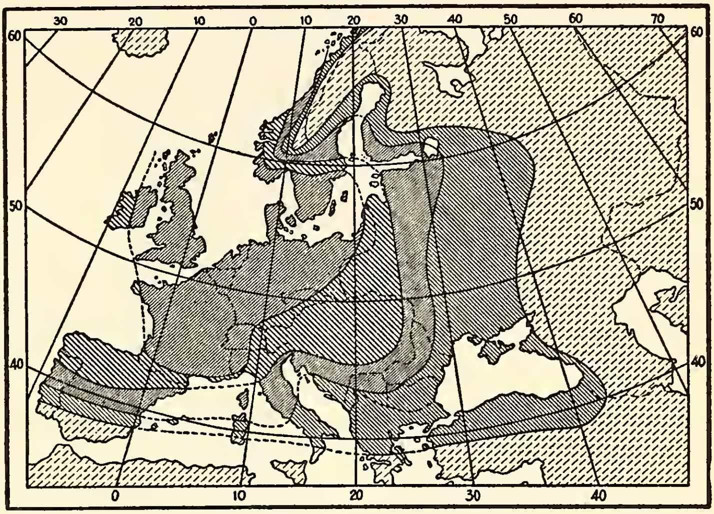

Fig. 7: *Distribution of climatic energy in Europe. The darkest zones corresponds with those regions that are the most stimulating. The climatic energy decreases outwardly from the area around the North Sea. (From the studies of Ellsworth Huntington.)*

These geographical conclusions, however synthetic, deserve analysis. *A priori* it might seem that the most favorable climate for the development of materialistic civilization would be that in which the temperature is at the point of constant thermal neutrality most favorable to activity, with occasional slight stimulating variations. Empirical observations, however, reveal that regions enjoying an agreeable climate with relatively uniform temperatures are peopled by indolent folk. A yearly temperature range of 62.5° F. is therefore indicated as desirable.

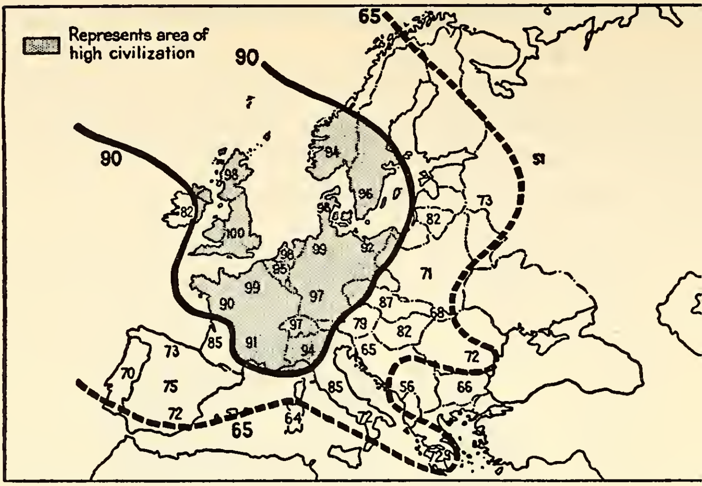

Fig. 8: *Civilization in Europe. The shaded area represents the regio[n] with the highest degree of civilization. The numbers correspond, in de[-] scending order, with the degree of civilization. (From the studies of Ell[s-] worth Huntington.)*

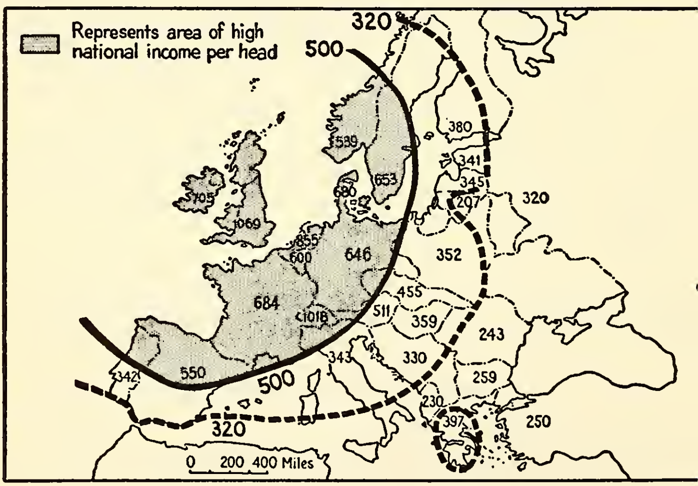

Fig. 9: *National income in Europe. The shaded area represents the ar[ea] of highest income per person, based on international units for the deca[de] 1926-1935. (From* Climate and the Energy of Nations, *by S. F. Mar[k-] ham.)*

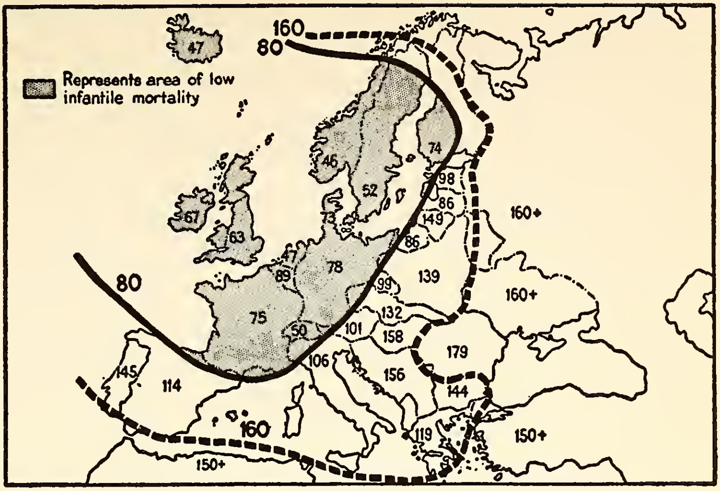

Fig. 10: *Rate of infant mortality. The shaded area represents the lowest mortality rate among children.* (*From* Climate and the Energy of Nations, *by S. F. Markham.*)

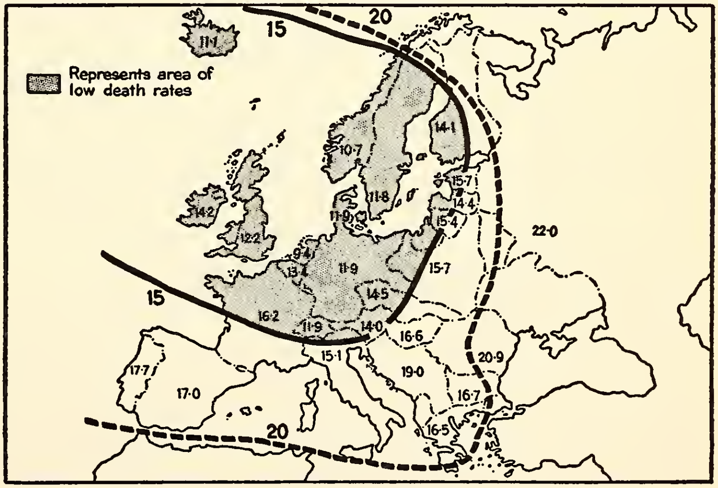

Fig. 11: *General mortality rate. The shaded area represents the lowest mortality rate.* (*From* Climate and the Energy of Nations, *by S. F. Markham.*)

There is no doubt that high temperatures are anything but desirable. Above 64.5° F. in normal clothes or 71.5° F. in lightweight clothing, the waste of energy in the struggle against heat fatigues and weakens the human organism. Body resistance is reduced and the vitality of pathogenic bacteria is increased. Mental activity and energy decrease unless the periods of heat above 71.5° F. are short and infrequent.

At the other end of the thermometer, the temperature should be sufficiently low at certain periods to permit strenuous manual labor, particularly farming. And since human vitality and energy are linked to peak metabolism, man must be periodically exposed to relatively low temperatures in order to maintain his vigor. Yet the temperatures must not be too low—not below freezing, at any rate. Extreme cold stultifies mental activity, and the energy absorbed in maintaining the heat balance—despite warm clothing—saps physical strength.

We would be wrong if we tried to define the ideal climate in terms of adults only. The future of a civilization depends upon the formation of its youth. It is well known that too mild climates do not stimulate the energy of children, while rugged climates do induce their growth into strong and resolute men.

To carry this study beyond the point at which American geographers have left it, we should take into consideration the relief of a country, for material civilization is more or less bound to transport and facility of access. An altitude greater than thirteen hundred feet is disadvantageous.

Finally, taking all factors into consideration, we may estimate that the most favorable geographic conditions for the industrial activity of Europeans are: average temperature of about 32° F. to 36° F. for the coldest month, and 61° F. to 65° F. for the warmest month; annual rainfall from twenty-four to thirty-two inches; regular variation of the temperature from day to day; elevation not more than thirteen hundred feet.

Using these criteria, France may be divided into three zones

favorable to industry. The first, which matches the optimum conditions very closely, comprises the Nord (French Flanders) and the Lyons and Clermont-Ferrand basins. A second zone, slightly less favorable because it is a few degrees too cold in January and a few degrees too warm in July, includes Lorraine and the Ardennes. The third zone, Alsace, is another degree or two less favorable in summer and winter. All other parts of France are still further from the most desirable conditions.

It is worth remarking that if we make note of all cities in France employing more than five thousand workers in the three principal industries (textiles, metallurgy, chemicals), we will find that every large industrial center (except the ports, which are dependent upon the sea) will fall within the favorable climatic zones. And the density of the factory areas increases as the climatic conditions approach the ideal. To those who may object that the underground riches may have something to do with the location of factories, we may point out that the industrial activity in these zones is very old and antedates the exploitation of underground wealth.

Since the case of France justifies our hypothesis regarding presumably favorable geographic conditions, it is interesting to study Western Europe on the same basis. We find five zones of decreasing climatic worth, departing from ideal conditions either by excessive heat in summer or cold in winter, or because of excessive or insufficient rainfall. The countries which at no point within their boundaries enjoy ideal climatic conditions turn out to be the countries with little industry. What factories there are, are found in zones closest to the climatic ideal.

Is there a connection between the density of population and climatic stimulation? Both studies show some analogies and marked differences. It is normal that the population should be denser in regions of favorable climate. The history of the frequency of invasions demonstrates that the appeal of these regions has long been known, and the fact that they have a lower death rate makes them doubly appealing. And yet some

zones of Central Europe are quite densely populated, but without development of industrial civilization. For this we may well blame the lack of favorable climatic conditions.

Although racists may be tempted to claim confirmation of their theories in the above conclusions, the maps of Carlenton and Stevens Cook do not support them. True, the distribution of pigmentation does show some analogy with climatic stimulation: the more enervating the climate becomes, the fewer blue-eyed blonds there are to be seen. But despite the conviction of Gobineau and Georges Vacher, it is not certain that there is a causal relationship here. The two phenomena may simply be concomitant.

And the considerations that follow show that this connection between physical type and the growth of a civilization has been apparent from century to century.

III

Civilization on the Move : The Climatic Theory of Huntington : Markham's Explanation Based on the Development of Heating

Economic history shows us that the Nordic countries tend to replace the Mediterranean regions as standard-bearers of civilization. The explanation is simple enough: man is learning to correct unfavorable climate. More and more he has learned that artificial heating can nullify the ill effects of cold. Moreover, it is incontrovertible that civilization has been moving—geographically—in the course of the past centuries, and that none of the regions where it is today most developed is the birthplace of an original civilization.

Huntington has tried to explain this movement by a change in climate, a theory which is justified by numerous geological arguments. The mean temperature of Greece at the time of her

glory, according to Huntington, approximated that of New York today.

Markham, on the contrary, insists that climate has not changed materially, but that the movement of civilization to the northward is due to the perfection of heating procedures. Before artificial heating made its appearance, when men were only summarily clothed, the most favorable climatic regions sat astride the annual isotherm of 70° F., provided, of course, that the land was fertile and the air neither too dry nor too humid. This was the case in the north of Egypt, Palestine, Assyria, and the Babylonian area. Egypt and ancient Mesopotamia were particularly favored by the absence of mountains and the large number of navigable rivers, which are, of course, natural means of communication. So it was in these regions that civilization, in the generally accepted sense of the word, first arose.

Subsequently the center of this civilization moved progressively toward the regions in which heating appliances were being perfected. It seems that the Spartans were the first to build hypocausts—flues that carried hot air from a furnace into the floors and walls of all rooms. The system appeared in Greece in the seventh century B.C. and was adopted by the Romans shortly thereafter. The Romans developed it to a degree that was never reached by the Greeks or Persians.

In ancient Rome the public baths were huge buildings which also housed theaters, libraries, and music rooms. Their tepidaria—warm sitting rooms—were open to the general public in cold weather. But although they served as centers of culture and business, they were first of all places of luxury, and in this respect they were violently attacked by the Christians during the fourth century. The growing contempt for comfort helped in the decline of the baths, which were progressively abandoned, while civilization moved toward Constantinople—leaving the thermal establishments behind. As a result, civilization turned again to Arabia. It is worth noting that the apogee of Greek and Roman civilization corresponded with the peak of

popularity of the heating systems—and that decline followed their abandonment.

The return movement of civilization toward the 70-degree isotherm marks a regression, and it was not until it started moving toward the cooler countries that progress was resumed. With the perfection of heating systems following the discovery of coal, civilization continued its progress to the north. From Spain it moved into France, England, the Low Countries and Scandinavia. Similarly power passed from Austria to Germany.

The same assertions may be made for the Americas. The annual mean temperature of the high plateaus where the civilization of the Incas, the Mayas and the Aztecs developed is slightly lower than 70° F., true, but we must also note that solar radiation is more intense in these regions.

Markham claims that all evolution of civilization is closely linked to the potentialities of heating, which are dependent not only upon the technique of the apparatus, but also on the art of construction and on fuel resources. Some countries, such as Chile, are badly handicapped by the scarcity of energy sources. Thus, while the climate of Santiago and Valparaiso is comparable to that of Auckland and Wellington or of Sydney and Melbourne, the level of civilization in Chile is far below that of New Zealand or Southeastern Australia. New Zealand has the lowest infant mortality rate in the world (40 per 1,000 living births) and Chile one of the highest (238 per 1,000). And New Zealand has four times the fuel supply and ten times the electrical energy of Chile.

Markham's thesis is attractive and must contain much more than a grain of truth, since it is thanks to heating that human production can be kept at maximum during the cold season. Thus the progressive northward movement of industrial civilization is limited by the wealth of the Nordic countries in combustibles and in electricity.

We might apply the same reasoning to the warm regions since we now are able to cool off buildings during hot weathe

The comparison involves considerable reserve, however, for men do not spend all their time in air-cooled interiors, and an outside temperature of 82° F. is certainly more disadvantageous than a temperature of freezing corrected by proper clothing.

It would be arbitrary to attribute the development of civilizations to climatic factors alone, although there is no doubt that they are major influences. Race, nourishment, religion, and material resources are equally important in varying degrees. And it is the resultant of all these influences which causes the rise, the stagnation, and the regression of a country. Huntington notes judiciously that the natural excellence of food on the shores of the Mediterranean has played an important part in the appearance of the first civilizations in these regions. Moreover, man was unable to conquer the more northerly areas until he possessed implements of husbandry sufficiently efficient to attack the forests of the north.

In any case, the white man, drunk by his own success and inclined to attribute his superiority over other races to heredity alone, is generally unaware of the debt he owes to the physical conditions of old Europe.

IV

Colonial Climates : Adaptability of the Whites : Historic Examples of the Jews and the Anglo-Saxons in the Bahamas

But, some souls will protest, is not the influence imputed to climate being exaggerated? The North African countries are beginning to be industrialized and some bolder eyes foresee even the possibility of developing in the tropical colonies a material civilization comparable to that of the temperate countries. Nothing actually proves that the earth there is not as rich as in Europe, and if the natives are lazy, why not send down enterprising workers to replace them? For, after all, the

industrial life does indeed require active, healthy men. All we need to know is whether or not they will remain permanently healthy and active in an equatorial climate.

There are two schools of thought in the matter of acclimatizing the white man to the tropics.

The Dutch believe acclimatization is indeed possible. Those of the Dutch school deny that there are variations in metabolism and thermic constants when the white man leaves home for the tropics—variations which the work of Ruth Benedict seems to confirm effectively. The Dutch conclude that if the Nordic follows strict hygienic measures, he will live and perpetuate his race in the hot countries. The Germans and a few rare Britons agree.

The American school, with the support of most Britons, holds the opposite view. From their experience in the Philippines, the Americans believe that metabolic disturbances and nervous exhaustion are inevitable in the hot countries. The white man transported to the tropics first goes through a period of nervous overstimulation, followed by a general slowdown of all his physiological functions, which is finally expressed in a loss of nutrition. This stage is sometimes accentuated by excesses of all kinds, particularly venereal. Recourse to stimulants during the period of overexcitation merely aggravates the depression which follows. The system thus debilitated is an easy prey for the epidemic and endemic diseases which flourish more readily in the tropics than in the temperate zone.

The annals of British colonization, richly documented, are clearly opposed to the theory that Nordics may be permanently acclimatized to the tropics. Moore declares flatly: "I say that both experience and logic are against the founding of a family by a European and against the survival of his descendants maintaining the same mental and physical characteristics, either on the plains or in the hills of the tropics." Although the experience of Queensland may seem to invalidate this conclusion, we must remember that the Australian coast is

tempered by the trade winds and that, in spite of this, some observers have noted a tendency to premature aging in the region.

Portuguese and Spanish colonization, particularly in the Antilles, confirms the fact that the Mediterranean peoples are more adaptable than the northern peoples. The Iberians, who have become so well acclimatized in Cuba, already showed their great resistance to extreme conditions during the Russian campaign of 1812.

Be that as it may, nobody questions the fact that profound psychic and somatic changes occur during a white man's acclimatization to the tropics. Since even relative success is largely dependent upon physiological soundness, only the best specimens have a real chance of succeeding. Even then the human organism must have periods of respite, either through long home leaves or by long vacations at hill stations where the climatic conditions are less harmful. Such great colonial powers as Britain succeeded in maintaining their influence in inhospitable regions only by rotating officials, so that personnel served alternate terms at home and in the colonies.

Could this respite be obtained on the spot by suitable cooling of the tropical habitat? Clarence Mills foresaw the building of air-conditioned barracks for white troops in the colonies, in which they could spend at least one-third of their time.

Whether there is a possibility of permanent acclimatization —that is to say, perpetuation of the white race in the tropics— seems questionable, for in a very little time the "acclimatized" white man becomes quite different from the original transplant. Different foodstuffs and a different climate develop new qualities and new faults which would not appear in a North American or European milieu. Activity in particular, for purely physical reasons, cannot be the same as that in a temperate climate. It is futile, therefore, to talk of transplanting the white race to the tropics, for the successful transplants very soon bear little resemblance to the first conquerors.

A few historical facts may illustrate these conclusions. The obvious difficulty of such comparisons is that of finding, in different climates, men having the same hereditary patrimony. And with variation in diet also, it is difficult to distinguish the exact action of the climate. However, certain migrations which deserve to be studied still further offer a few general indications.

With the fall of Jerusalem, the Hebrew race was scattered throughout the world. Through their religious laws and practices, the Jews have maintained a certain racial unity and standardization of dietary habits, so we may admit that the patrimony of the race on the whole has remained more or less the same. Now the Jews who emigrated to India, Abyssinia, and other tropical regions have showed a distinct decline, materially as well as intellectually. Until the fifteenth century the most eminent Jews were always Palestinians. But as the center of civilization moved northward or toward the New World, the Palestinian Jews were overshadowed by their coreligionists in Northwestern Europe or in North America. Today the most outstanding Jews are natives of these regions.

Another example, which has become classic in scientific literature since Huntington's research, is that of the Anglo-Saxons of the Bahamas. At the time of the American Revolution, a number of English loyalists emigrated either to the Bahamas or to Canada. Statistically, we may take the heredity of these two groups to be the same. Their descendants in Canada have become distinguished citizens, playing a prominent part in the life of their country, while those in the Bahamas are comparatively inefficient. Those in Canada are all well educated; many of those in the Bahamas are illiterate, or if they have gone to school, they forget easily what they have learned. The principals themselves admit that the climate of the Bahamas engenders indolence, and even present-day American emigrants to the islands quickly lose their active energy after a few years' stay. And yet malaria is unknown and the tem-

perature range is not extreme. It is the very monotony of the climate which seems to induce indolence.

Another example, less typical but equally plain, is that of French colonization in Algeria. Other things being equal, the families which have settled in the higher, cooler regions such as Miliana or Constantine are physiologically much better off than those which have colonized the warmer parts like Orléansville and Bouira.

The most convincing example is perhaps that of the degeneration so many whites experience in climates too different from that of Europe. These "poor whites" represent one of the gravest problems facing the southern United States, India, South Africa, and some countries of South America. Their degeneration may be such that these "poor whites" become inferior to normal natives. According to some semi-official figures, three hundred thousand of the two-million-odd whites of South Africa fall into this category.

It is remarkable that these people seem to have maintained a normal level of intelligence. Markham notes that the "poor whites" of South Africa are the issue of the best European stock—Dutch, German, French and British—and that their decadence appears only after several generations. He attributes this particularly to the fact that the colonials become progressively more and more careless about protecting themselves from the extreme climate. In fact, those who live under the worst climatic conditions are those whose degeneration is most marked. They may be rehabilitated by urban employment with accompanying improvement in living conditions, which proves the somatic character of their decadence—a more accurate term than degeneration, in fact, except when there has been unfavorable intermarriage.

All these conclusions apply to Nordics. It is they who do not adjust to the tropics. On the other hand, the Mongolian race both in its Asiatic branch and its American offshoot, the Indians, shows a remarkable climatic adaptability. Its domain ex-

tends from the tropics to the Arctic Circle, from Tierra del Fuego to Alaska by way of the Equator. The blacks in some ways are equally adaptable to both equatorial Africa and the temperate regions. The Negro farmer of the northern United States is often more efficient than the white farmer of the South.

So we may say that the Nordics who have turned the world upside down are more than any other peoples the slaves of their original climate. They cannot take their civilization with them unless they can also take along their climate.

Moreover, this condition is not pertinent to man alone. Zoologists have long known that warm-blooded animals from cool climates are not easily acclimatized in hot countries, although animals from the tropics stand up perfectly in the rigors of a northern winter.

But it is this condition which will sooner or later limit the dream of hegemony of the white man, particularly of the blue-eyed blond. Unless, of course, he should learn to overthrow the climate of inhospitable regions. Even then he would be living in a caricature of natural conditions and it is questionable whether he would bloom as profusely as in his original climate. And would he not be severely handicapped in relation to local races when everything would be equal in other respects?

This is the tragedy of colonization, which carries within itself the seeds of its own destruction: the decline of the cultural and material superiority of the transplanted European.

5 ✳ THE SOCIAL AND PSYCHIC INFLUENCES OF CLIMATE

I

Climate and Character : Northern Severity and Mediterranean Sensitivity : Morals and Climate : Politics and Religion

"Man has more vigor in the cold climates," writes Charles, Baron de Montesquieu in his *L'Esprit des Lois.* "This greater strength must produce many effects, for example, more self-confidence, which means greater courage; greater awareness of his own superiority, which means less desire for vengeance; greater sense of security, which means greater frankness, less politics, fewer intrigues.

"In the cold countries," he adds, "man will have less feeling for pleasure. It will be greater in the temperate countries, extreme in the warm countries. The same will hold true for pain."

And he concludes: "In the north countries a healthy, well-built, somewhat heavy machine finds pleasure in whatever sets the spirits in motion: hunting, travel, war, wine. In the north-

ern climates you will find people who have few vices, a fair amount of virtue, much sincerity and candor. Approach the lands of the south and you will seem to be leaving morality itself behind: more violent passions will multiply crimes; everybody will seek to take advantage of everybody else to favor those same passions. In temperate climes you will see peoples capricious in their manners, even in their vices and virtues. The climate is not determined enough in character to give them stability."

The influence of latitude on character has been disputed by Voltaire, who finds that "the illustrious author" exaggerates in his constant affirmation of the superiority of the peoples of the north. In any case, we may well wonder if Montesquieu was well informed on the characteristics of all European peoples, for it would not seem that the politics of Eastern Europe have anything to learn from the Mediterranean peoples when it comes to guile.

The climatic differentiation of races has been more recently examined by Hippolyte Taine in his *History of English Literature.* "Climate," he writes, "has had its effect. Although we can trace but obscurely the history of the Aryan peoples from the land of their common origin to the countries they occupy today, we may nevertheless affirm that the profound differences between the Germanic peoples on one hand and the Hellenic and Latin races on the other, derive chiefly from the countries in which they have settled. The former have made their home in cold and damp lands, in the rugged depths of marshy forests or on the shores of a cruel ocean, wrapped in violent or melancholy feelings, inclined to coarse food and drunkenness, given to hunting and fighting. The latter, on the other hand, live in the midst of fine scenery beside a shining, laughing sea which beckons to navigation and trade, free from the gross demands of the stomach, drawn from the outset toward social habits, toward political organization, toward the sentiments and talents which develop the art of speaking, the gift of enjoyment, the invention of the arts and letters."

So from the same premises we see one author affirming the incontrovertible superiority of the northern races while the second author reasons their marked inferiority. Before passing judgment, therefore, we must establish, more or less subjectively, a hierarchy of values.

In the natural state, life in the north is an almost perpetual struggle, for the fight against cold demands an abundant diet rich in meat, which man could originally obtain only from the hunt. It is not surprising, therefore, that he should develop more courage and energy than he would in the more friendly Mediterranean climate, where the easy life and gentle temperatures are more suitable to dreams and idleness. These sunny shores must naturally have become the cradle of the fine arts.

Inhabitants of temperate lands, slightly cooler, share the characteristics of both peoples. Divided between action and inspiring meditation, they were perfectly fitted to upset natural conditions. With progress, the attenuation of the rigors of winter by artificial heating permitted them to maintain their level of creative activity throughout the bad seasons, and the resulting rise in their standard of living allows their thinking to surmount immediate material constraints.

From these differences in living conditions spring naturally the more or less profound divergences in manners, morals, and life itself. Morals are essentially a set of rules for practical living designed to achieve the greatest statistical happiness. The same act may be of no consequence in certain climates and immoral in others. Alcohol, for instance, is a danger in very hot climates and is forbidden by the law of Mohammed; but in cold climates alcoholic drinks, by their high caloric content, are sometimes useful and comforting. In countries with a low level of sanitation, women are more numerous than men, for infant mortality rates are higher for male children; and monogamy is less natural than in temperate regions where the numerical inequality of the sexes is less marked. Hospitality depends essentially upon the severity of climate; it is a sacred duty in countries where a traveler without shelter

is exposed to certain death; it reaches a perfection which seems excessive to us with the Eskimos, who without restriction puts his entire household, lock, stock and women, at the disposal of the stranger.

A social order obviously depends upon the character of the individuals which compose it. In warm, unstimulating climates, general passivity allows the establishment and duration of authoritarian regimes. The listlessness of the Negro explains the tardy disappearance of slavery. On the contrary, in stimulating climates vigorous men given to reflection and discussion rapidly become enamored of justice and jealous of their liberty. It was in the north of France and in Belgium that the first free communes appeared.

If we examine the map of climatic stimulation in Europe, it is quite clear that with rare exceptions the democracies are to be found in the most stimulating regions. It matters little whether they be republics or constitutional monarchies, the democracies are characterized by great individual freedom of action and especially of thought. Moreover, we should not pass definitive judgment on the transitory form of a government, but rather on the historic tendency it represents. It may be that during particularly critical periods the democratic countries may accept a dictatorship of short term or even long, but it is also true that other regions, such as Russia, are currently incapable of democratic existence. The Russian revolution of 1917 has merely replaced a decadent autocracy by an efficient dictatorship. Events since 1940 have confirmed the following conclusion: authoritarian regimes are settled in the countries of Eastern Europe and the political opposition between them and those countries enjoying a more stimulating climate is self-evident.

Dictatorship, almost always supported by a strong army, confers upon peoples of inhospitable climes a military superiority over the democracies of the more friendly regions. And since the northern races seem always to yearn for sunny shores, there are periodic invasions in the direction of better

climates. If the afflux of "barbarians" seems temporarily to slow the march of civilization in western Europe, the migrations make the hardy races from the colder countries to the north more fecund in all fields. Then as they become acclimatized, they become more refined and debilitated—and the cycle begins again. Throughout the world there are melting pots waiting to dissolve the energies of neighbors.

The influence of climate on character is also reflected in sectarian matters. Dogmatic or sentimental religions do not easily find followers in very stimulating climates. Protestantism was to find root in the Anglo-Saxon countries and in the north of France. Luther was a native of Saxony and Calvin was born in Noyon, in northern France. Religious fanaticism and resigned fatalism appear only in burning sunshine or in the most rugged climates. Atheism flourishes only in climatically stimulating regions.

Study of political and religious tendencies in the French provinces shows that climatic influences may be found even in a geographically limited region. Research by André Siegfried has demonstrated that, making allowance for the religious policies of Richelieu and Louis XIV, the Reformation made most of its converts in those parts of France with the most stimulating climate—regions which today show liberal tendencies and vote largely to the Left. Regions with more uniform climate, such as Britanny and the Vendée, have remained deeply Catholic, conservative, traditionalist, even Royalist. It is worth noting, incidentally, that the same cantons have been voting in the same political direction for nearly a hundred years now, and that these cantons may be grouped in aggregates of the same political shade.

We have here a geological and climatic phenomenon. Communities more than three thousand feet above sea level generally vote to the Right. The more stimulating cities contain a larger percentage of Protestants and free thinkers than the country districts. The cities vote to the Left, even when the surrounding rural communities are conservative.

6 * CLOTHING

I

Importance of Air Layers in Protective Dress : Evaporation of Water Vapor : Partial Nudity : Wardrobe Heresies : Questions of Color

Everyone concedes that the purpose of clothing is to prevent the escape of body heat, but few laymen realize that the thermic resistance of any given attire depends much more on the layers of air imprisoned between the several folds of the garment or in the fabric itself than on the nature of the textile. The fibers of wool, cotton, linen or silk are all practically equal as conductors of heat. We have knitted a garment of fine copper wire, using tiny stitches and painting the resulting fabric black, which is almost as heat-insulating as cotton or wool as long as the layer of air immobilized between the stitches is the same thickness in all three garments.

A less-known role of clothing is that of caloric flywheel. It serves in a measure as a regulator of ambient temperature just as the walls of a building serve to moderate variations in the outside temperature.

When the body is defending itself against excessive heat, the cooling evaporation of perspiration is efficacious only to the extent that the materials of the clothing allow the passage of water vapor. When the fabric is only moderately porous, such as linen, moisture gathers copiously on the skin and the clothing is soaked with sweat. Damp clothing loses its heat-insulating quality and when the body passes from effort to repose, contact of the damp cloth with the skin may cause dangerous chills. Rubberized fabrics are even more of a menace. Textiles with woof threads parallel or in the same plane—which means most clothing fabrics—are purely artificial in concept and have no equivalent in nature. Animal fleece, for instance, is easily permeable to both air and water vapor. The closest man-made textiles are the rough woolens made of unfinished yarn, and flannels and knit goods in which the fibers do not all run in the same plane. Is it pure chance that scientific study has revealed their superiority to more artificial concepts?

Another difference between human attire and natural fleece is that man-made garb is impermeable to ultraviolet rays. Animal fur is never so thickset that the rays cannot reach some part of the epidermis. Partial nudity in the presence of sunshine, therefore, particularly in children, is essential to the adequate production of Vitamin D.

As stated earlier, the physiological purpose of clothing is to regulate heat losses of the human body in order to achieve a status of thermic neutrality in relation to its activity. Accordingly some sartorial prejudices border on stupidity, for clothing ordinarily worn inside the house, while satisfactory in winter, is superabundant in summer, thus lowering the resistance of the human organism. Scientifically, we must therefore applaud the liberality of American custom which permits workmen simply to wear light trousers and a shirt open at the collar. The same attire could well be recommended for outdoors wear on hot days, providing the system is not exposed to sudden changes of temperature. This example, it should be noted, has

already been set by sportsmen, who are often the forerunners in matters of science, and on a larger scale by young nations and virile peoples, whose taste for action takes priority over prejudice.

The importance of color in attire is not generally well understood. Physicists know that color plays a negligible part in the emission of heat by radiation at low temperatures. A black or white garment, all other things being equal, will transmit body heat in the same manner. But color plays a major role in *receiving* heat by radiation at high temperatures—solar radiation, for instance, especially the visible wave lengths. Dark colors absorb more radiation, so dark clothes are more efficient in winter. In summer, however, when the body has trouble giving off its heat into the environment, solar radiation is definitely not needed and light-colored clothes are in order. The high black silk hat which used to be so stylish at the turn of the century, even in summer, certainly deserved its nickname of "stovepipe," for the summer temperature of the air inside was often close to 120° F.

By varying the thickness of his clothing, a man can compensate for a variation in ambient temperature of a score or more of degrees. However thermal comfort does not only depend upon the temperature of the skin; the temperature of the air inhaled is also a factor.

It would seem that the air temperature most stimulating to the lungs is from 54° F. to 57° F. But the sensation of cold on the exposed skin makes most men prefer an ambient temperature of about 65° F.—the sunny ideal of a pleasant spring or autumn day.

II

Scientific Research into Dress : The Thermic Ideal for Infants : Dr. Carrel's Cradle-Incubator

The paucity of scientific research into a field as important as attire gives some idea how retarded are the sciences of man.

It is quite possible that the tunic and square cloak of antiquity—with their looseness permitting the air to circulate and therefore affording thermic regulation—were superior garments to the sheaths in which we now imprison our limbs and bodies and whose form, if not thickness, is determined by decorum alone.

It took World War II to set off real scientific research in dress among the belligerents. From the start of the Battle of France in May, 1940, the stupidity of the accoutrement of certain troops was apparent to the combatants. The French infantryman, sweltering in the hot sun with his heavy cloak, his heavy knapsack and trappings, retreated on foot while his enemy, in light trousers and open-neck shirt and carrying only one light weapon, rode to the battle line by truck.

When the United States entered the war, American laboratories at last took up the science of dress, adapting the U.S. uniform to the climatic conditions of the various theaters of operations. The result was a truly rational outfit for the American army, by which some of the allies also benefitted.

These researches demonstrated that even in cold climates it was dangerous to cover the entire body, because exposed surfaces detected temperature changes more quickly and thus hastened the defense reactions of the body. They also showed that thickened fabric at the bending joints increased heat loss by increasing exterior surface area. Further experiments are being made with materials which will contain air between crossed fibers as well as between layers. And, of course, plastics are in some measure replacing the classic textile materials.

Dress, we should point out, has four functions, both subjective and objective: protection against climate; maintenance of

body cleanliness; response to modesty and standards of decency; and satisfaction of the esthetic sense, according to style and the desire to please. The first two points are achieved by separating normal dress into two parts, the one which makes contact with the body washable, the other concerned with insulation. The considerations of esthetics and decency vary with the times and the place.

The practical problems of dress have always seemed elementary because every adult regulates his own attire according to his sensations of cold or warmth. But in the case of children too young to express themselves, objective knowledge is necessary to meet conditions of age and environment. During his first months, the suckling babe requires special heat conditions which are different from those of an adult because he has a smaller coefficient of heat production. Certain newborn animals, like chickens and guinea pigs, are born fullfledged homoiotherms, capable of locomotion and feeding themselves. Others are forced to keep to the nest for a period which some biologists compare to the incubation period of chickens.

The first experiments by Baccino in the laboratories of Lapicque on the thermic requirements of young animals were carried out on young rabbits, removed from the mother and raised at various temperatures to determine the influence of temperature on their growth and their resistance to infections and poisons. Baccino demonstrated that there is an optimum temperature for each age group, and that excessive heat is as harmful as cold. The optimum ambient temperature diminishes with age, while the thermic tolerance increases. One of the most remarkable of Baccino's discoveries was his demonstration that the optimum conditions duplicated exactly those of the natural nest of the mother. By its construction, entirely closed at first and opening gradually as the little rabbits grew, this nest produced the ideal temperature for each age.

The ideal natural conditions for the human suckling have been lost in the night of time. In their random and improper

protection of newborn infants against the cold, many mothers show ignorance of the harmful nature of excess heat. Difference in clothing makes it impossible to fix ideal thermic conditions very rigidly. Clothing aside, the simplest method would be to set skin temperature according to age, and experiment shows that it decreases regularly during the first year. From 95° F. to 96.8° F. at the age of one month it drops to around 86° F. at ten months. But measuring skin temperature underneath clothing is difficult for many reasons. It is easier to specify the garment necessary for the infant at each age according to the surrounding temperature. Therefore a treatise on child care should contain a clothing table as well as a feeding chart.

Another method which we studied with Dr. Alexis Carrel consisted in placing the infant naked on a washable hammock contained in an egg-shaped cradle. The cradle was completely closed except for an aperture for the child's head. In these conditions clothes were done away with completely and thermic conditions regulated by controlling the temperature inside the cradle. This temperature should vary from 93° F. at one month to 81° F. at ten months.

Aside from the advantage of doing away with clothes, except during nursing periods, this apparatus could also be adapted (with the addition of a little ice) toward the reduction of infant mortality in the tropics. The chief cause of death of white infants in the tropics is hyperthermia, the cause of most infant intestinal complications.*

The work of Baccino is strikingly similar to that of Malleray. In thermic protection, as in nutrition, we have lost our primordial instincts and science has not yet been able to replace their vital, basic knowledge.

* The Carrel cradle saved work for the mother by abolishing diapers. The by-products of digestion accumulated in a receptacle underneath the hammock. Experiments with this apparatus, begun in Strasbourg in 1938 with the cooperation of Dr. P. Worringer, pediatrist, were interrupted by the war and unfortunately never resumed after the death of Dr. Carrel in 1944.

7 * THE HUMAN BALANCE SHEET AND ARTIFICIAL CLIMATES

I

Protection and Remedy : The Dangers of Abuse : The Continuing Need for Outdoor Life and Changes in Climate

To argue about the influence of civilization upon human happiness would be as puerile as it would be futile. Yet we may nevertheless examine the balance sheet of this civilization to study certain advantages, such as those of artificial climates.

There is no doubt that by protecting the delicate moments of existence against external rigors we have certainly added to the prolongation of the average life span. In raising the rate of human production in all fields, we have contributed to raising the standard of living. At the same time, we have not added to the longevity of men endowed with natural good health, and may, in fact, have been injurious insofar as we have deprived healthy man of his natural efforts at adaptation. Since life is no more than a reaction against environment, the complete blossoming of a man's personality requires the activation of all his natural functions. So to safeguard the integrity of the adaptive faculties, he must use the artificial climates with discernment and particularly shun temperatures above 65° F.

The American tendency to heat rooms to 75° F. is a crime against hygiene. It would probably be better for us if we went back to the days when 60° F. was considered warm enough, even if we had to wear more clothes. And during hours of sleep, because of the influence of air temperature on breathing, 50° F. or 54° F. is plenty.

We must be especially suspicious of engineers who, ignorant of the sciences of man, solve all problems with a slide rule. Thermostats which have been so perfected that they can control temperature in living quarters to within a quarter of a degree should be thrown into the ash can—if they worked as well as they were supposed to. Actually they work accurately only under laboratory conditions. Happily in an apartment house there are many reasons—among them the inertia of the building—which makes their precision far less than that guaranteed by the manufacturer.

We can never insist enough that rugged climates make rugged children, that climatic changes are a source of strength and energy. Inhabitants of temperate climes could do much worse than send their sons to grow up in the mountains or under less clement skies. We might even see a phenomenon like that which accompanies invasions. Men raised in more severe climates become more fertile in the stimulating climates than if they had spent their childhood there. Would this not be true from the other end of the scale?

Finally, climatic conditioning may help men whom our mechanized civilization places in abnormal conditions. Let artifice answer artifice, for man was never meant to fly in the cold of high altitudes or dig miles under the ground. And since the white man degenerates rapidly in the tropics, if he wants to live there permanently, he must take his climate with him.

Pessimists may wonder if all tampering with the natural order is entirely fortunate, and if it is really desirable to permit the survival of delicate specimens which would normally disappear with the process of natural selection. There is no doubt

that artificial climates, like the science of medicine, do expose themselves to a charge of collectivism. But that is the process of civilization. The collective conscience, impregnated with the Christian spirit, rises up against Spartan practices and rebels against the thought that the inadequate must be abandoned to die.

We must underline the pretentious term "artificial climates," for it is something of an oversimplification to define an environment only in terms of known elements: temperature, humidity, air pressure, light, electricity, wind. There are certainly factors now unknown, analagous to vitamins in nutrition, which exert just as much influence on the human organism. In fact, it is not certain that the comparison is at all far-fetched since men have been known to live for years in cells which were badly lighted and ventilated. They did not live in perfect health, true, but they did not seem to have been deprived of the very factors absolutely essential to life, such as vitamins.

The very fact of filtering sunlight through a pane of glass makes grave changes in "climate," for the ultraviolet radiation is much reduced if not altogether stopped, and the glass induces what German hygienists call "biological night." That's why children, and even adults, should be exposed as much as possible to natural climate out of doors. Dr. Carrel used to say, half facetiously, that "houses should be built with very small windows so that people would feel the urge to go out more." It is to be feared that the great picture windows of Le Corbusier, "incorporating the landscape into the rent," give a dangerous illusion of life in the open, and thus an advantage becomes a disadvantage through ignorance.

Artificial climates, although they may be only caricatures of nature, at least afford an escape, if man so desires, into natural conditions from time to time. And yet civilized man may live all his life in complete ignorance of a healthy, natural diet.

Man must struggle against the monotony of environment in the widest sense of the term. He must eat different things, he must move from place to place—if only from room to room.

8 * PHYSICAL CHARACTERISTICS OTHER THAN CLIMATE

I

Physical Geography : Colors, Sounds, and Smells : The Possibility of Olfactory Harmony

It is somewhat narrow to reduce physical environment to terms of climate alone, for the contours of the land, colors, noises, and odors exert a certain influence upon the formation and behavior of living creatures.

It is the province of the anthropogeographer to determine in what measure man is marked by the sea, the plains and the mountains. The lives of the mountaineer and sailor are in general harder and more dangerous, and they, as a result, usually have more steel in their characters, even though they are sometimes doomed to inactivity by the weather. Broken country builds character. A peasant living in a village which for now forgotten strategic reasons was built on a hilltop and who has to climb up and down daily between his fields and his home, usually turns out to be an energetic factory worker when he abandons the difficult life for the city.

In Lorraine, for instance, the last ridges of the Vosges have both human energy and hydraulic energy on which to base a successful textile industry.

Although the effect of color on the psyche and behavior of

man has been known since earliest antiquity, it has been analyzed only recently. Color certainly influences thermic sensations: red, pink and yellow are warm colors, while blue and white suggest coolness. In factories where workers have complained of the cold, painting the walls coral pink stopped complaints without raising the temperature by a single degree. Dark glasses in a sunny environment reduce the impression of heat. Conditioned reflexes are probably involved here, red and yellow evoking the color of fire, white the color of snow, blue the cold of a freezing day without clouds. The warm colors have longer wave lengths.

Colors also suggest variations in density. Black objects seem heavy, while white or light blue suggest lightness. An American factory found that when heavy boxes once painted black were repainted a light green, they seemed much lighter to the handlers.

The emotional effects of color are well known. The seven primary colors of the solar spectrum, as well as white, black, and gray, all have their own meanings. Red, a stimulating color, is synonymous with passion, even anger, and finally produces nervous overexcitement followed by depression. Yellow has a more measured effect, building nerve tone and suggesting happiness. There is a proverb which says: "A pretty yellow will overcome any sadness." Green and blue are calm colors, generating serenity and euphoria. It is probably for this reason that it is so restful to contemplate a lovely spring landscape on a fine day. White stands for brilliance, loyalty, even timidity; it also symbolizes solemnity in action. Black evokes sadness, fear, and death. Gray suggests wisdom and seriousness, but in a landscape is oppressive.

Green and blue are essentially the colors of broad daylight, while red and yellow are those of sunrise and sunset, which bolsters the idea that the rhythm of activity of the first men was that of the wild mammals—more nocturnal than diurnal.

Although the murmur of a brook or the rustle of leaves in a light breeze are restful sounds, complete silence in nature

evokes a feeling of dread. Is this because all living things grow silent at the approach of danger? Violent sounds, like those of thunder or a storm, arouse in simple souls a feeling of terror that is often mystic.

The noise of a city is a handicap to work and a menace to sleep. One of the advantages of artificial climates is that ventilation may be accomplished without opening windows to the urban cacophony.

Although music is used today in many workshops to stimulate the workers, the technique of its use is still being studied in relation to its nature, its timing, and its rhythm in ratio to the rhythm of work.

Although sight and hearing have been responsible for the origin of the first arts of the first civilizations, the sense of smell has always been neglected. True, the material difficulties are quite complicated. Sounds can be produced by the simplest means. Color requires slightly more complex means. But the artificial reproduction of odors calls for a highly advanced chemical industry. And yet the psychic influence of olfactory sensations is very great. The exalting aroma of gunpowder and the aphrodisiac effect of some perfumes are classic examples.

Furthermore, nothing fixes or revives a memory more than an odor. Is this because perfumed sensations are so rare that the memory is not crowded with them as it may be with sight and sound recollections? Or is it because the sensation of smell is particularly direct and violent? Here is an artistic field which has scarcely been scratched.

A priori, there is no reason why we should not create olfactory harmonies just as we create musical harmonies. Huysmans did experiment with spraying various perfumes into a room, suggesting the mountains, the prairie, or new-mown hay, and succeeded in composing a veritable soul-landscape. Baudelaire and François Coppée were among our most olfactory poets. Baudelaire's *Flowers of Evil* is redolent.

Most people summarily classify smells as good or bad. The

bad smells, which provoke a sense of disgust, usually arise from surroundings tainted by life or by animal decomposition. This repugnance seems to be an instinctive defense explainable by recent research into air-borne contagion. The good smells—the fragrance of flowers and the open countryside—perhaps owe their effect, at least on the city dweller, to association with the idea of freedom. Then there are certain scents associated with sex which are very seductive during the period of excitement and repulsive once the senses have been gratified.

There is little analytical literature in this field. According to Oscar Wilde, "incense transports us to mysticism, amber to the passions of love . . . violet awakes in us the memories of loves long dead . . . musk disturbs the mind and jasmine the imagination. . . ." This confused lore is of little use except to perfumers, who are chiefly interested in increasing the attraction between the sexes rather than in artistic theory.

But today, with the high state of perfection of our chemical industries and the possibility of distributing fragrance through air-conditioning systems, there can be no *a priori* objection to the creation of a new art form based on a succession of olfactory sensations, just as music is based upon a succession of aural sensations. The fact that odors tend to impregnate objects with which they come in contact is a difficulty which may be solved by modern techniques. Another problem is the special physiology of the sense of smell: the olfactory nerves become rather quickly accustomed to an odor, and we can no longer smell it after a time. It seems also that there is a wide divergence in subjective judgment of odors, more so even than of sounds. But these questions are still too little known for us to begin formulating general rules.

Although the sense of smell is less developed in man than in many animals who depend upon it to guide their nutrition, it is far from atrophied. Smell is still the best way to judge the degree of pollution in the air upon entering the room. The nose is far more accurate than any meter extant today.

IV *Education and Psychic Environment*

1 ⁎ GENERALITIES

I

The Aim of Education : Social or Individualistic? : Essential Hierarchy of the Ends : Courage, the Basis of Virtue

If we accept the Cartesian principle that body and soul are separate, nutrition and climate would influence only the material portion of the individual, while the educational or social milieu would influence the spiritual part. This was not one of Descartes' lesser errors—not to mention the cult of reason to the detriment of instinct. It is obvious that the body has a strong influence on the mind and vice versa. If education, in the broadest sense of the term, consists in the development of the physical, intellectual, and moral faculties of a child, then nutrition and climate are as much involved as the educators. However, this section will be largely devoted to the psychic action of the social milieu on the child's development.

Our initial difficulty is not to define education as such but to fix its aim, for we must know what we want the child to become. The question is a complex one. Some authors and

philosophers believe education should pursue individualistic ends. According to Aldous Huxley, education consists in "raising young human beings with a view to liberty, justice, and peace," which can only be the endowment of a man without ties. Johann Herbart believes the aim of education should be "to form the individual for himself in awakening in him the multiplicity of interests." Georg Kerschensteiner goes further still: for him education consists in the distribution of culture so that "man may organize his values in his conscience and in his own way so that they may conform to his own individuality." Charles Renouvier, believing that man improves as he develops, sees in education a means to perfect him, for "man perfects himself when he approaches as closely as he can complete fulfillment according to his nature." A similar idea is held by Henri Joly, for whom education consists of "the combined efforts to the end of giving a being the complete possession of his diverse faculties and the means to make the best use of them."

Emmanuel Kant, who has some reservations regarding the excellence of human nature, assigns to education the end of developing in the individual "all the perfection of which he is capable." The same idea is advanced by John Stuart Mill, who sees education as an avenue for bringing us closer to "the perfection of our character."

May we say that for these last authors education is clearly individualistic in nature? It may nevertheless be considered social in the sense that the more a man perfects his character, the better he will get along with his fellows.

Renouvier's definition may be considered social if we admit that it is in the nature of man to live in society. This is probably true on the whole, but manifestly inaccurate when applied to some individuals. In any case, natural or not, life in society has certainly developed and grown stronger over the ages. This is probably the result of the growth of the world's population, the density of the population, and consequently the development of agriculture and the rationalization of labor.

It is an essential factor in human evolution, on the same level as a biological law, that life in the world as it now is cannot exist except in organized society. Since education cannot ignore these primordial needs, the theories of sociologists must necessarily contradict the individualistic tendencies of Huxley and Herbart. In fact, Emile Durkheim defines the goal of education as the development in a child of "the physical, mental, and intellectual conditions required of him by the political society and social milieu to which he is destined to belong." And James Mill, seeing a practical objective, wants education to make the individual into "an instrument of happiness for himself and his fellows."

So the line is clearly drawn between the individualists and those who see a social purpose in education. Obviously we are dealing with man's happiness and his self-esteem. But from the strictly pragmatical viewpoint of James Mill, isn't individual happiness a function of group happiness? What's more, individualistic education must be rejected as anarchic. History shows that during periods of disorder, members of society as a whole are unhappy, and it is always the weakest and most lowly who suffer most. So we find that, in the philosopher's conception of Utopia, education must always be social. But the social ends to which education tries to pass on the torch must be pointed toward the dignity and happiness of man in the widest sense. Society has the right to shape education to fit its own ambitions, but it is an awesome responsibility to choose these ambitions, for the individual must not be bullied out of his highest aspirations for any reason of state, which is no more than the tyranny of the masses.

Since no society may rightly claim to pursue indisputable aims, we must admit that the individual has a right not to subscribe to them as long as he does nothing to prevent their fulfillment. The group must agree that this reserve and this tolerance are among the ends of education. Whatever we may think of British democracy, we cannot fail to bow to the British respect for conscientious objection. And yet these dis-

sonances must be the expression of aspirations transcending the objectives of society and not the consequence of the selfishness of asocial elements. Total sacrifice—as The Passion—is, of course, the sublime criterion. The conscientious objector is self-obligated to go between the lines and collect the wounded, friend and enemy alike.

So that education, in the restricted sense outlined earlier, may be defined as "the sum of all actions, direct and indirect, taken to prepare a child or an adolescent the better to fulfill the role which society reserves for him at all ages, and to incite him to contribute to the pursuit of common social aims, while allowing him by disciplined and disinterested criticism to ennoble those aims."

The required qualities, of course, derive as much from individual morality as from social morality. Although the former has a certain constancy throughout the world, the latter may undergo numerous variations due to the form of the particular society as well as its customs and ideals. In any case, these variations are relatively minor in advanced societies, and there exists a certain unity of morals with geographic variations.

If the moral qualities required by life in society are diverse, they are nevertheless classified and graded, and it is the duty of education to underline those of fundamental importance.

"Morality," Alexis Carrel once said, "demands that man love his neighbor. He must therefore first of all make himself amiable." In his relationships with his fellows, man must prove his honesty, integrity and sense of justice, all qualities which basically require great sincerity. He must be patient, tolerant, devoted and generous, all qualities which derive from charity. He should be disciplined, and therefore humble. In the exercise of a profession, he needs, beside his professional knowledge, conscience and perseverance, which add up to courage. And if man is to assume responsibilities in the social hierarchy, he must be endowed with character, energy, and unselfish devotion, qualities which are other aspects of courage and sincerity.

So we may sum up the four essential social qualities as sincerity, charity, humility, and courage. On second thought, they may even be reduced to two; for charity is a form of courage, and humility is merely sincerity with oneself. The basic virtues are therefore courage and sincerity.

Intellectual courage and the humility necessary to recognize our own wrongs are perhaps difficult to achieve. That is why there are so many hypocrites.

If courage were not at the base of all moral values, our best citizens would not make the best soldiers in time of war. For the myth that bad boys are potential heroes does not stand the ordeal of fire.

II

Difference between Education and Instruction : Is Education Possible?

We must first determine whether or not man is educable.

Speaking only of moral influence, there are some children on whom education will have no effect whatever since they are fundamentally rebels. Although they are a small minority, these abnormal cases seem either pathological or the result of an initially defective education which has warped them permanently. Other children are so totally devoid of character that they absorb all influences, good or bad, and still remain amorphous. They, too, seem to be pathological.

Current study, however, indicates that the vast majority of children may indeed be oriented in the direction of good and of knowledge. The failures are quite understandable: ordinary methods are necessarily adapted for the average child, which means they are valid only statistically. There is too little provision for the deviation from the mean—either the backward child or the abnormally brilliant child.

Sometimes failure is due to the contradiction between pre-

cept and example. It is not surprising that moral instruction remains a dead letter when the child sees the moral law constantly violated either by his teachers or by his family.

We should be able to determine the limits of education by comparing twins. We have authoritative documentation here in the field of intellectual education, through the use of intelligence tests, but the moral field is more difficult to assess. Research shows that when monozygotic twins are raised separately, the one brought up in the more intellectual environment has the higher I.Q. The I.Q. tests do not prove native intelligence but intelligence in action, a quality which apparently improves with use.

Comparison of moral values is more complex. There is, of course, the criterion of penal records, but this is only a rough method. Nevertheless German educators have combed the records of twins, seeking parallel involvements with justice. They did find an area of agreement in the criminal records of identical twins, but as most of the pairs were raised together, the result can hardly be called conclusive. Nevertheless, the comparison of criminal records of fraternal twins showed far less parallelism. In the case of identical twins, the conviction of one brother involved his twin in 71% of the cases, whereas with fraternal twins there was double conviction only 38% of the time. The figures thus indicate that milieu is not alone responsible, and that heredity plays an important part.

It is highly interesting to know exactly what happens to children abandoned soon after birth and subsequently cut off from all human contact. While experiment is difficult, it has been achieved involuntarily in different circumstances. According to witnesses, some of them worthy of credence, a number of wild children have been found who have been raised by bears, wolves, and leopards. The known cases have been analyzed by an American, Dr. Robert Zingg.*

* *Scientific American,* March, 1941. The usual explanation of the animal-children is that they were perhaps nursed by female animals which had lost their young by accident, and thus sought relief through suckling by

These children walk on all fours, and have senses much more highly developed than normal children, particularly the sense of smell. They obviously do not talk, and understand only through fear and anger. It is notable that children found after the age of five or six were almost impervious to the use of language and never learned to form sentences of more than three words, no matter what the duration of their civilized lives.

So it would seem that all that man knows, aside from the most rudimentary gestures, is the product of his environment. But we must not go all the way with Lock, Baboeuf and Proudhon, who believe that "man is the equal of man." In other words, education can develop the same talents in all. Rousseau is closer to the truth when he says: "Trying to make a fool into a man of talent is like trying to make a blonde into a brunette." This, however, is oversimplification, for what we are really trying to do is teach men to use their potential talent.

What's more, this importance of the milieu is a function of the vigor of the talent. An idiot will get nothing whatever out of instruction. A man of superior intelligence probably needs no teachers to learn. But the average intermediate masses will profit greatly from all intellectual and moral teaching.

In a word, the effective influence of education can no more be denied than that of heredity. After all, the whole debate is rather futile, for if all efforts to mold the minds and characters of men had been sterile, education would have been abandoned long ago.

Can we divide education and instruction and give each of the words a definite and independent sense? In its common usage, education includes everything that should prepare the child for his life in society and for better understanding of his fellows. Instruction, on the other hand, is the study of human

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the children, independently of the physiological need of maternal love. The best-known case is that of the two little girls of Minapore, raised by wolves and observed by a Hindu pastor named Singh.

knowledge and experience. So according to current thinking, education derives from the home and family, and instruction from the school.

This is obviously an arbitrary division. If schools had no other purpose than to teach a portion of human knowledge, their end product would be deplorable. For what adult man remembers even slightly the things he learned in class? "Culture is what remains in the intelligence when man has forgotten what he has learned." So what we call instruction is really a formative process. Besides, if education aims to develop the moral capacities, instruction—by the effort and sincerity it demands—often plays a more important role than the confused efforts of the parents. True, if the parents were aware of the hereditary tendencies they had transmitted to their children, they would be better fitted than anyone else to orient the children's development. But do they always have the necessary courage and objectivity? To punish a child is often self-punishment. The role of the parents, therefore, is more often to suggest by example than by active direction.

Education is thus the sum of all the efforts, active or passive, made by members of a society, parents or teachers, for the best fecundation of the seeds of the qualities and potential talents inherent in the hereditary patrimony of the child.

Instruction, *per se,* has a much more limited sense. It is the sum of all operations by which the child is familiarized with the knowledge necessary to fulfill effectively his role in society.

Certain branches of knowledge, which Hubert called "instrumental," are truly basic. The most elementary are language, writing, arithmetic—in sum, the fundamentals of our primary instruction. Other fields, equally instrumental, are more special and technical, pertaining to the professions. Still others concern the rules and customs of society and are generally the province of the family.

There remains the mass of learning having no immediate utilitarian character but which gives man a better understanding of the universe. The subjects are scientific or philosophic,

religious or artistic. They may also be sources of happiness and of enjoyment.

III

Methods of Education : Didacticism and Intuition : Concepts of Natural Education : Libertarian Education and Its Failure : Psychic Ontogenesis

Knowledge has two sources. It may be transmitted by one person already initiated or it may result from personal discovery.

Knowledge through didactics—that is, taught—may remain verbal, incomplete, even erroneous. The instructor may not always be able to communicate. The attention required of the pupil may not always be stimulated by curiosity.

Knowledge by empirical means, on the contrary, requires acuteness and observation, making the mind more receptive and consequently more deeply marked.

The various methods of education derive from these two sources of knowledge. The dogmatic method teaches by means of authority. The child remains passive and is supposed to assimilate without argument, sometimes even without discernment, the principles and the learning imposed upon him.

The natural or intuitive method, on the other hand, reassures the child, allowing him to develop himself and placing confidence in the good of human nature for the normal blossoming of morality.

Between these two extremes we find active methods which rely partly on didacticism but do leave some initiative for the child to participate in the discovery of the laws and principles of social conduct and human knowledge.

It is apparent that the same method is not suitable for both moral education and instruction. If the child can be brought to recognize the necessity for moral laws as more or less pri-

mary truths, it would be difficult to keep him from discovering for himself the social conventions, arbitrary though they may be, as well as acquiring the intellectual legacy of past generations. The quarrel between dogmatic and natural methods should thus be studied differently for character formation than for intellectual education.

To the credit of the natural method, we must recognize that learning is not really assimilated until it has been put to practical use. The mind always proceeds by induction, so that dogmatic instruction, which operates largely by deduction, should be illustrated by experience. Even in mathematics a general law is not really understood until after several applications. And the practice of a profession is merely theoretical instruction put into action.

It is in the discovery and teaching of the instrumental virtues and knowledge forming the basis of personality that the intuitive method is pre-eminent. For purely cultural matters the didactic method is necessary because the years set aside for education are very short.

The so-called "natural" method is intended to appeal to intuition alone. It is subject to so many interpretations that some precision is necessary.

The idea is the result of reaction against the abuses of didactism and the principle of authority. We should, first of all, understand that one of its primary purposes is to knock down the watertight bulkheads separating dogmatic teaching from real life. After ten years in boarding school, what experience or knowledge of life can an adolescent have? There is a true need to bring education closer to reality.

The term "natural" also applies to the desire to allow the child to develop without constraint according to the laws of his own nature. Which comes down to saying that natural education is obliged, according to the concept of Rousseau, to be purely negative if not nonexistent, as in certain extreme modern concepts in which "the child runs no danger of being lazy because he is never ordered to work."

Natural education in this totalitarian concept was recently tried out in Hamburg, where the pupils were given every liberty, including the right of not attending classes. The failure was complete and resounding.

All tendencies are actually potentially present to some degree in every child, and the object of education is to direct their emergence, and not allow them to develop haphazardly at the mercy of environment. Since society is a human creation, the social bent exists in everyone. The best proof of this is that even the most selfish child seeks the company of playmates.

It seems that we may speak of a certain psychic ontogenesis in the course of childhood and adolescence. Just as the fertilized egg runs through the whole cycle of biological evolution before its intra-uterine life culminates in childbirth, the child is born with the instincts of primitive man, and during the course of his formation, he goes through every stage of civilization. Even if we could anticipate that a purely natural development would bring out the best in man, we must remember that all societies have certain conventions, and there is no reason to suppose that the free development of children would lead them to conceive the same conventions. What would become of a society if men were to have opposing ideas on all basic questions?

In conclusion, let us agree that the natural method in its broadest sense—that is, libertarian—is indefensible for practical reasons. Development of the child should be controlled.

2 * CHARACTER BUILDING

I

The Limits of Actual Education : Training for an Autonomous Morality : Educating the Critical Sense of Adolescents : The Problem of Obedience

Although purely dogmatic moral education leads sometimes to failure, it is not inconceivable. Abstract knowledge of the moral principles is not enough; their need must be felt. The child should therefore be associated in the discovery and application of these principles. Education should not be purely theoretical, but experimental as well. This is the active method in its true sense.

The child is born ignorant and incapable of reflection. Perhaps as he grows he will become aware of the moral principles. In any event, children left to themselves reach their eighteenth year with the habits and morals deriving from the milieu into which chance has placed them—and which are not easily uprooted.

Education, necessarily dogmatic at the outset, begins on the day of birth. The child takes habits conforming to the de-

mands of society and of hygiene. He can be taught them only by constraint. The natural egoism of the child should come into collision with the social and hygienic requirements with the same rude suddenness as the rebellious child knocking his head against a wall. The moral restraints should appear to him as inexorable as the law of gravity.

There is no substitute, in achieving this end, for early training both at home and at school. Training may have a repulsive sound to those who associate it with animals. Trained horses, trained dogs—animals forced to acquire habits which have nothing in common with their natural behavior. But does not life in society require the abandonment of certain natural reflexes in favor of social reactions? What difference is there in the training of a hunting dog to point at a game bird instead of leaping upon it as he would do naturally, and the education of a child to give back a piece of candy dropped by a little friend? Or to refrain from taking the biggest piece of cake on a platter? None, really. And the training is more efficacious when the child—like the puppy—is young and malleable.*

To be successful, training must have the cooperation of the child through understanding and acquiescence of conscience. At this point morality ceases to be heteronomous and becomes autonomous by recognition of the necessity for good of a superior nature, be it of natural, social, or divine origin. In

* Training is obviously no more than the acquisition of conditioned reflexes which by repetition become habits. This training in its negative form leads to the inhibition of natural reflexes. Life in society requires the taming of natural (but selfish) tendencies. The well-brought-up man adjusts with ease and therefore with great efficiency because he has been correctly conditioned; that is to say, his natural reflexes which are social have been developed, while the others are sufficiently atrophied so that he does not have to watch them constantly. The power of such training is demonstrated by Pavlov's classic experiment: A dog, by much repetition, is taught to overcome the pain of an electric shock and actually to drool in anticipation of the pleasure of the meal which always follows the ordeal. Which caused Sir Charles Sherrington to say: "I now understand the psychology of martyrdom."

other words, by his own consent. Consequently, as his means of reflection and appreciation develop, it is proper that the child should participate in this education.

The need for this cooperation was apparent even to the old didactic teachers, who would seek to complete the training of the child by convincing lessons. In its usual dogmatic form, this moral teaching is generally grossly inefficient, judging by what remains of it in the adult. Let discipline relax in an army, egoism reappears and men become cowards. Let bonuses be awarded in a factory by collective initiative and injustice becomes flagrant, only to disappear again at the first show of authority, either by labor or management. Curiously, the various moral qualities are linked together. The rule which restrains bad instincts encourages the emergence of qualities apparently unrelated. In a well-commanded brigade—or well-managed factory—the solidarity and comradeship among the soldiers or workers is incomparably greater than in an undisciplined brigade or factory.

For morality to become really autonomous, the dogmatic method must evolve with age into the active method and disappear completely when man is sufficiently developed. It is obviously rather difficult to fix the limits of the various stages in terms of age; but for an average child moral teaching should gradually lose its dogmatic character between the fifth and seventh years, the period at which the conscience appears. A little later the child should learn responsibility for his own behavior in relation to himself. A few years more, and he will become aware of his responsibility for his behavior to others through his experience in the miniature society constituted by his playmates. Toward his eighteenth year, when the adolescent makes his first acquaintance with philosophy and metaphysics, education should be as objective as possible, without concealing the artificial character of spiritual or social structures. The adult man must later be able to return to this point in the light of his own critical views and his experience of life.

So we may say that the natural development of a child's personality demands that moral education begin by being dogmatic, that it become gradually active, and that it finish as far as possible with the greatest objectivity.

But this objectivity must not be presented as a step to license. Obedience is a necessity. Social upheavals, source of so much suffering for the masses, are convulsions of authority. And those who have preached indiscipline have no other resource, after achieving power, than to restore obedience—often by dictatorial means.

There is no question but that authority needs a check. In the intermediate echelons, the control comes from above. It is at the top that the danger lies. For believers, the check is Divine Justice—in other words, obedience to a transcendental power which in all religions represents morality. For atheists, if the moral sense is not high enough, the natural check is the judgment of the executants, judgment—even when silent—which is eloquent to anyone who can read faces. For one can obey, by discipline imposed or freely accepted, and still be contemptuous. The humble, like children, have a true notion of morality even when they themselves have not the character to conform.

Our future leaders must recognize that they will be judged with fairness and discernment by their inferiors. Like the fear of Divine Judgment, this responsibility before collective morality is one aspect of the transcendence of moral law.

II

Early Training : Automatism : Moulding Sentiment by Suggestion and the Control of Physical Posture

Early training of the child may be accomplished through bypassing his consciousness. There are three basic means for doing this:

1) Formation of automatisms, transposing to the human level the elementary phase of training animals.

2) Molding of the sentiments by suggestion.

3) Formation of an entire personality, including the mind, by control of physical attitudes.

Training sets out to create, by conditioned reflexes, automatic responses the necessity for which will be understood by the child later when they are part of his subconsciousness. This is especially true for the most elementary of social rules: obedience, politeness, good behavior.

These automatisms are comparable to those which must be learned during an apprenticeship to a trade, freeing the mind from the attention and nervous capital which would otherwise be necessary for the conscious and voluntary performance of minor actions. The performance thus becomes more rapid and more perfect, for an automatism is always quicker and more accurate.

Training should begin at birth. Its seat is the animal memory, which appears in a child very early. Suckling babes must be taught habits of obedience and cleanliness from the very first day. Under the cloak of indulgence, many mothers hide their basic laziness and cowardice, for it is easier to give in to a baby clamoring to be fed than to let him howl until the time set for his regular feeding. This type of training may—depending upon the child—require more or less strength of character, but sooner or later the baby will understand the futility of his cries and tantrums. Training, human as well as animal, brooks no weakness. It is difficult to teach a horse to jump after it has been allowed once to refuse a hurdle. Months of effort in teaching a child obedience may be undone by a single moment of indulgence.

The business of education requires a strength of character not always found in professional teachers and still less often in parents, whose natural complaisance toward their offspring is not compatible with the application of strict rules. How many professors accept what Alain (Émile Chartier) calls

"humiliating contracts" in allowing their pupils to busy themselves with whatever they please as long as the class remains silent?

The child who learns obedience early from his mother and his first teachers should have no trouble complying painlessly with the essential laws of society. Otherwise he must resign himself to them painfully, after trying experiences will have shown him their inexorability. The betrayal of the parents and the teachers in this respect is of the same character as that of chiefs on any level who by softness or laziness permit disobedience although they are fully aware that it is contrary to the general interest.

But aside from automatisms, primary education should orient the child toward that complex behavior called human dignity, in stirring him to reactions conforming to the moral law. To this end we might use the reversibility of the ideomotor cycle. For if a gesture is the motor expression of a thought, the involuntary sketching of the same gesture stimulates the psychic sphere which would have produced it in the first place. So we may say that physical movement influences thought.

This law is the basis for all military education, so it would be childish to underestimate its efficacy. It imposes a physical posture calculated to produce a desired mental attitude. Standing at attention is designed to prepare the soldier to execute an order as well as to be a physical attitude of respect for superiors. Insistence on impeccable dress is supposed to make the soldier proud of his uniform and his status.

If educators sometimes forget that sentiments may be molded by posture, they are also too often unaware of the power of all types of suggestion—suggestion which dictators and some businessmen misuse for questionable purposes. Children, like men, are normally against submitting to the ideas and will of others. This resistance is suppressed during hypnotic sleep, when the hypnotist may impose his will not only for the moment but for actions beyond the point of awakening.

Suggestion is based on the experimentally proved fact that man generally ends by accepting an idea if it is skilfully presented over and over again. Perhaps this is because his will to resist is worn down in the long run, and the idea slips into his unconscious in moments of inattention or weariness.

Although suggestion is exercised principally by spoken or written expression of the thought, it is also quite efficacious by direct action upon the senses. Perhaps the oldest example of this is music, which not only "hath charms to soothe the savage breast" and ". . . the savage beast," but may also excite the soldier to combat. That is why the manner of speaking and the tone of a command may sometimes carry more weight than the words themselves. The tone of voice is music to which the speaker himself is susceptible, since the fact of forcibly stating an opinion acts to confirm the orator in his own convictions; another reason why children should be taught to speak clearly and distinctly.

Just as arbitrary is suggestion by color. The shorter wave lengths, like red, have a stimulating effect, while the longer waves at the blue-purple end of the spectrum are soothing. The theater, painting, sculpture, architecture, photography, and the motion picture are other aspects of suggestion through sight.

Suggestion by smell seems to have been less utilized than by the other senses—except for perfumers. There are odors which excite, odors which intoxicate, odors which calm. Every soldier who has known combat knows that the fumes of gunpowder are a heady scent. How much of this power of suggestion is inherent in the nature of the smell and how much due to conditioned reflexes is hard to determine.

Probably the most efficacious of all forms of suggestion, since it is used in all religions, is that of the litany. A child or group of children repeating the same phrases endlessly cannot help being impressed eventually.

There is evidently quite an art in the use of suggestion, not only in its form and dosage, but in the choice of time and

place most favorable to its receptivity. For the audience must be relaxed before being convinced. This technique has certainly been more widely and profoundly studied for the purpose of moving manufactured goods than for improving the moral and intellectual level of our children.

Finally, there is one aspect of suggestion which must be insisted upon, because it is not well known and many parents and teachers through their ignorance make use of it in a contrary sense. We are speaking of the form of addressing children. How many educators have called a child a liar and a lazybones because he has lacked sincerity or has tried to avoid some task? Exactly the reverse approach is the proper one! The child should be persuaded that the error cannot be repeated "because he is neither a liar nor a lazybones." If a child is accused repeatedly of being a liar, he will end by believing that he is one and will make no effort to curb his desires to lie. For him the case is closed and probably hopeless. Worse yet, he will believe that his title gives him the right to deceive. The teacher's exhortation "You should not lie" shows scarcely more understanding of the power of suggestion.

The authors of the Boy Scout code were wise. The Scout Law does not say a Scout *should be* kind, brave, loyal, and so on. It says, "A Scout *is* brave, a Scout *is* loyal," and so forth. Just as a man accused rightly or wrongly of a crime feels qualified to justify the accusation, a favorable judgment conveyed to a child confirms him in the idea that he is worthy of it, and gives him the strength and desire to live up to the judgment. This form of suggestion is found daily, even hourly, in human contacts of daily life. A woman sometimes commits adultery for the simple reason that her husband has previously accused her of it unjustly.

This aspect of suggestion appeals to the child's participation to the extent that we seek to awaken in him the desire to justify a favorable opinion. It creates a transition between methods which are purely dogmatic and the active methods. Although necessary at an early age, even before the child can

take real part in his own education, the suggestion is potentially active for it awakens the responsibility of the child anxious to justify a flattering reputation.

III

Esthetics and the Moral Sense : First Responsibilities : Pets and Playmates : The Humor of Mark Twain : The Innate Morality of Children : The Family Influence

The advantage of an active method of education lies in its adaptation to the individual child and in making use of each favorable element as it appears for his character development. The esthetic sense appears in a child before the moral sense. Even small children are repulsed by ugliness. Therefore educators are correct to say that falsehood is ugly rather than that falsehood is bad.

This attitude is valid through the sixth or seventh year, directing the child away from everything ugly in his posture as well as behavior. We may thus conclude a sort of honor contract with him, without his being aware of it, which will induce conditioned reflexes of enthusiasm for the beautiful and repugnance for the ugly.

Beyond the seventh year this contract may be based on his sense of justice, which is more developed in the child than in the adult. It is probably his first manifestation of a social sense. The beautiful and the ugly are still purely egoistical ideas with the child and allow him to acquire a sense of responsibility to himself. With the idea of justice, that of responsibility to others also appears. It is obviously difficult to give a very young child important responsibilities in regard to his playmates, so we must use subterfuge. An excellent method is to give him complete charge of a young animal—a puppy, a rabbit, or a bird. Experience will teach him very quickly that it is impossible to cheat on the laws of nature. But we must have the

courage to give full play to implacable natural laws, even to the death of the cherished animal through the child's carelessness or forgetfulness.

Later, at about the twelfth year, we may give him responsibility for his comrades or his elders. To this end some new institutions confide to students tasks formerly assigned to teachers. They become monitors of classes, study halls, and dormitories. The jobs must be essential in order that the student be inculcated with a real sense of responsibility, and must fit the qualifications of the student. It is puerile to suppose that the exercise of elementary responsibilities will lead a child to discover the moral principles for himself. The most we can expect is that he will see the need for certain social rules, and if education has ceased to be dogmatic, it is none the less heteronomous. Training by schoolmates takes the place of training by teachers, and the more or less limited character of school life cannot give a child experience with moral law in all its fullness.

For this reason some active schools have been organized into veritable communities which approach real life as closely as possible. Aside from the École des Roches in France, one of the most famous of these experiments is the George Junior Republic at Freeville in upstate New York, which constitutes a state in miniature, with the material and social life of the colony strictly dependent upon the work of the students. However, these are still experiments and permit of no generalization.

Moreover, there is little need to teach normal children ethics and morals, for they often have a more developed moral sense than adults. What they need is the will to apply the moral laws which on occasion they reproach others with transgressing. Contacts with teachers are generally too limited for the adults to give the children the moral benefit of their experience with life. It is only in the family that the child generally sees the diverse aspects of existence, and it is here that he forms his moral concepts. Not that parents are any better

teachers of morals than professionals, but the behavior of the family circle is suggestion by example. Even when they seem to be listening with only half an ear to the conversation of grown-ups, children are impressed by the remarks of parents on their superiors, their equals, even their inferiors.

Parents too often neither know nor care about this definitive influence. It is of course a real chore to be continually watching one's tongue in the presence of children, but this is a choice to be made. The child is a perfectionist. For him there are no men who are more or less truthful, but only those who never lie or who always lie. One lie may lose the confidence of a child forever. So the severity of some educators in their condemnation of customs and traditions tainted with falsehood is quite justified. What bitter disillusionment in a child when he discovers that his own parents have been accomplices in the humbuggery of Santa Claus.

Perhaps we should fear the formation of children too trusting in the existence of the best of all possible worlds, who would subsequently grow up to be facile dupes. But since they will be ultimately exposed to the ostentatious dishonesty, indecency, rudeness, and immorality of the street, the press, and the stage, the danger seems purely imaginary. The child is only too tempted to believe that the life which flows past on the outside is the normal life. He needs the example of a few educators in whom he has confidence to keep him uncontaminated by ambient immorality.

The task is facilitated, of course, when morality derives from religious principles. Among freethinkers, morality is sometimes justified for pragmatic reasons. In that case the whole matter must be placed on a statistical basis, so that the child will understand that the success, even lasting, of an unworthy creature is only an accident; that laziness and falsehood have a very slim chance indeed of succeeding.

This statistical character of the moral laws is a real stumbling block. How many children scorn moral teachings because in some cases immorality is not punished. Mark Twain

tells a pleasant little story of a bad little boy who, contrary to the readings of the "Sunday book," stole jam from the top shelf in the cupboard without the handy stool ever collapsing under him. He also copied shamelessly from the compositions of his classmates and was never publicly denounced by his professor.

This characteristic of probability should be expounded frequently as soon as the child is able to understand it. First, because it is a widespread scientific and human idea. Second, because there is no other way to explain the exceptions to the rule. Games of chance offer a convenient illustration. In all lotteries, the organizers keep for themselves a fairly important share of the take, so in the long run it is inevitable that the gambler will lose, despite any temporary winnings. Therefore, even in the pragmatic sense, gambling is immoral.

If the effectiveness of lessons in ethics is doubtful, the moral sense may also be developed by hero worship. No matter if these characters are idealized in presenting only their best side and in hiding their weaknesses, for youth needs enthusiasms. Moreover, it is in the "great books" of the ancients that we find humanity embellished and purified, mirroring the noble aspirations of everyone, aspirations that must be nourished and strengthened by suggestion and example. The army once forced recruits to read of the feats of illustrious warriors, for heroism is just as contagious as fear. All religions teach the lives of their saints. The life stories of admirable men are most efficacious as moral lessons.

But reading, even exciting reading, is not enough to mold the average child to better ends, for moral qualities, like the muscles, develop only with use. Character formation and the acquisition of a true moral personality may be achieved only by repeated efforts of all kinds. And it is here that the educational role of intellectual culture enters the picture.

IV

The Subjective and Educative Character of Happiness : The Myriad Examples of Happiness : "If"

Like most religions, the moral theses of antiquity equate virtue and happiness. This identification may surprise those who conceive happiness as a sum total of pleasures, since virtue entails self-denial. And yet observation finds statistical confirmation of Plato's declaration that "the just are happy, the unjust miserable." Not that happiness is the reward of virtue, but "beatitude is virtue itself," as Spinoza said.

It is true that more recent and more melancholy theses, based on "activity as the source of suffering," deny this optimism. But Kant, that sickly weakling, and Arthur Schopenhauer, his accomplice, are really malefactors. For happiness, too, is a matter of suggestion. There is more than a grain of truth in the method conceived in Aldous Huxley's *Brave New World* to inculcate happiness into children by repeating to them endlessly while they sleep that theirs is indeed an enviable lot. This more or less hypnotic suggestion in the Huxley novel is not less efficacious in waking hours. If certain social classes are so unhappy today, it is because bad shepherds—on the pretext of fighting real injustices—add to their unhappiness in repeating over and over again how miserable they are and inciting them to revolt.

So let us not pity a child to his face. On the contrary, let us emphasize his good fortune every time an event in the least happy comes his way. Better yet, encourage him to see unconsciously the favorable side of every happening. For men thus oriented, the most banal incident may be a source of simple happiness: a ray of sunshine, a brightly colored flower, a melodious voice, the smile of a child, a lovely woman passing by . . . but to enjoy them we need a freshness of soul.

All philosophy of happiness may be summed up in two

maxims from the sun dials: "I mark only the bright hours," and "All hours wound; the last one kills." The Kantian pessimism of the second is physiologically untenable, for within the limits of elasticity of the organism, action is the source of pleasure and happiness. Generous action spreads. Life grows lavish and elated in devotion and sacrifice, as Marie Jean Guyau conceived it in *Esquisse d'une Morale sans Obligation ni Sanction.* And the taste for action, and hence the road to happiness, may be given to a child through education, for it is a potential to some degree in all creatures. Certainly antisocial tendencies which oppose charity must be curbed by suitable training. But it is certainly easier to restrain instincts already atrophied in man than to housebreak a dog or to teach him to point at a bird he would love to devour.

If renunciation is the surest way to happiness, since the wise man is rich in all he does not desire, we must not become confounded by indifference or retirement into the shell, which are only other forms of atrophy.

Happiness is inscribed in the nature of man because all natural functions, even the less noble, are agreeable to the healthy creature. Only childbirth is an apparent exception and the painful character of this phenomenon may be due to the degeneration of modern woman. Everything leads us to believe, in fact, that among wild animals at liberty, there is nothing painful in delivery, only the undeniable joy of giving life. "Thou shalt bring forth in pain," the believer will object. But is not this fact due to the stupidity of civilized life? Weston Price has found that the closer women remain to nature, the swifter and easier is their accouchement.

We still have the problem of suffering and death. Disease is the fruit of our disjointed civilization, particularly of a deficient diet, of alcoholism, and to a lesser degree of the abuse of artificial climates which cause the atrophy of our adaptive faculties. Natural death by the gradual extinction of life is certainly the less painful. Incidentally, the importance attrib-

uted to death is linked to the level of civilization. In the old continent, it is a function of longitude and decreases progressively from Western Europe to Central Asia.

True, the loss of a dear one is also a physical suffering, for the bonds which unite us to our loved ones have organic ramifications. But is it not a selfish pain, conditioned by education? The bells toll when a bishop dies.

Popular truisms underline the subjective nature of happiness. One naïve saw declares that some men look at the world through rose-colored glasses, and others see only the dark side of life. Maurice Maeterlinck developed this thought eloquently in his *Wisdom and Destiny:* "What happens to us is pure water poured by fortune and has neither taste nor color nor fragrance. It becomes beautiful or sad, sweet or bitter, deadly or invigorating, through the quality of the soul which receives it. Let us not forget that nothing happens to us that is not of the same nature as ourselves."

To sum up, happiness may be defined as the propensity of the soul to retain the agreeable or elevating aspects of any event.

To what extent is happiness hereditary or acquired? The study of twins sheds little light on this question, for while intelligence can be measured, we have as yet found no test to weigh the sense of happiness. Be that as it may, there is in every child a hope for felicity more or less marked, and if some are less gifted than others, why give them up? We teach mathematics to pupils who can scarcely add. It is even more important to inculcate the sense of happiness, even into children marked by hereditary unhappiness. And no matter how mediocre the results, the effort is humanely worth while.

Since our destiny depends only upon ourselves, within the framework of our ancestry, children would do well to memorize Kipling's admirable poem "If," which depicts man as master of himself and therefore of his fate.

V

Backwardness of the Moral Sciences : No Criteria for Comparing Behaviors : Need of Tests for Studying the Evolution of Behavior

It is a curious fact that although most cultivated men agree on the prime importance of the spiritual, the study of moral sciences is currently very much retarded, judging from the development of techniques for observing the evolution of moral behavior under various conditions. Worse yet, the factors which affect such behavior have been badly enumerated and some psychologists are scarcely aware that they exist. Educators have been so busy measuring intelligence that they have had neither the time nor inclination to devise the equivalent of an I.Q. test to measure moral qualities.

The importance accorded to intelligence is based essentially upon the conviction that moral laws are rather elastic and may be avoided by adroit trickery. It would seem that civilized man, free of the vital struggle for existence, may stray from the natural laws without fear of instant extinction, as is the case with species still subject to the free play of selection. But the illusion is only superficial, for experience shows that societies which stray too far from the laws of nature, and hence the laws of morality, do end up by disappearing, either under the attack of the barbarians or by collapse through internal decay.

The backwardness of the moral sciences explains the difficulty of passing truly objective judgment on a period, or even of comparing one country with another at the same period and from the same point of view. This also explains national pride and the arbitrary declaration of superiority by one social system over another. It would be possible, however, to devise techniques for measuring moral levels with some approximation. For example, statistics will inform us on the frequency of certain actions considered immoral, such as murder, robbery,

and sex crimes, on condition, of course, that the state of repression and condemnation remains the same in both periods under comparison.

Nothing seems to stand in the way of a scientific study of the evolution of moral behavior under the influence of those factors which condition it. Tests comparable to the I.Q. tests, administered to a large number of subjects and maintaining other variables as constant as possible, would permit the study of the action of the physical and social milieu as well as of diet and education. No doubt the elaboration of such a test would be a delicate matter, for the elimination of possible fraud would be even more important, it would seem, in the moral field than in the intellectual. But there is no reason to believe that the inevitable period of trial and error would not eventually lead to effective techniques.

What a world-wide revolution if the degree of morality could be judged as closely as intellectual value!

The backward state of the moral sciences weighs heavily upon the destiny of peoples. Although college professors must meet strict standards to qualify for a job, the appointment to much more important posts on which a government or the fate of a nation may depend is left to the capricious judgment of the masses. This is partly due to the absence of valid standards for gauging moral behavior, and partly because every citizen regards himself as a competent judge of such elementary matters as moral values. And it is here that intelligence asserts its theoretical rights, for it is apparently intelligence which exposes the bad faith of candidates and the arbitrary or artificial character of systems proposed. But it is unlikely that intelligence is the true criterion when common sense, which is closer to instinct and therefore to moral sense, is the better judge.

It is for this reason that many intelligent and cultivated men can be convinced by false reasoning if it leads logically to erroneous conclusions, while men less susceptible to strict logic are harder to convince, since their conviction is based

more on feeling than intelligence. That is why intellectuals are sometimes taken in by a political system based on false ideas, but soundly constructed despite the precariousness of the foundation. The growth of logical intelligence multiplies the risk of erroneous judgment by the masses. The successful candidate is often the man who can present questions in the most favorable light, taking whatever liberty is necessary with the truth and good sense.

It is in this domain that the forms of knowledge are most clearly opposed: that deriving from the intelligence, in some measure external and heteronomous; and the inner knowledge, instinctive and autonomous.

True, even the scientific determination of moral values and the character of leaders would be subject to error. But do we consider bankrupt our system of admission to our great engineering schools, even though 10% of the entrants turn out to be incompetents?

Men of too great integrity are always in danger of being easily duped by the cunning ones. First of all, it is not certain that cunning confers lasting advantages, for if the advantages are based on lies or injustice, they must be ephemeral. "Lies have short legs," says the German proverb. And if good faith thrives, the chance of successful dupery grows rare.

People are all the more weary of diplomacy based on bad faith, which, despite temporary advantages, always ends in catastrophe, since man, with the massive means of destruction he now owns, can no longer play with fire.

Intelligence, which has been given to thoughtless free play without concern for morality, comes back to moral ideas because man is himself afraid of the evil he may do. The example of Alfred Nobel is rather deceptive. Fifty years ago the Swedish scientist erroneously believed that the power of his newly invented explosive would make the peoples of the world draw back in horror at the idea of war. But the hour is approaching when men will be seized by a salutary fear and a justified doubt of the motives which authorize them to sacrifice thou-

sands of innocents in the defense of regimes or ideas eminently debatable, in which it is not difficult to discern the part played by conceit and egoism.

It is highly significant that the American aviator who dropped the first atom bomb has retired to a monastery.*

Pierre Lecomte du Noüy once thought that the elite had a duty to hasten the moral uplift of humanity in promoting studies capable of revealing its genesis and its evolution.† For it is the intellectual elite which has allowed the development of the means of destruction and which should now turn its efforts to the improvement of man in abandoning researches the noxiousness of which is certified by centuries of history and this anguish which recalls curiously the temper of the year 1000. But the anxiety of 1000 was aroused by religious texts and had in the background the ultimate rescue of the faith, whereas our own anxiety is only one immense sense of despair for human kind.

* If this fact is untrue, and we have been unable to confirm it, this simply proves that the popular conscience imagines the man as tortured by the immensity of his responsibility, even though he was only carrying out orders.

† In other words, to obtain the "soul supplement" desired by Henri Bergson, "for humanity which groans half-crushed by the weight of the progress it has itself made." (*The Two Sources of Morality and Religion.* New York: Doubleday, 1954.)

3 * METHODS OF INTELLECTUAL CULTURE

I

Didacticism and Intuition : The Weakness of Active Methods : Erroneous Ideas about Interest-Curiosity : Examinations and Contests

In its broadest conception, the aim of intellectual education is to make the child aware of the universe, both living and inanimate, so that he may first understand it and later dominate it to the extent of human means.

In a much narrower sense, teaching may aim at the acquisition by adults of fragmentary knowledge strictly and immediately utilitarian, such as the instruction of army reservists being familiarized with a new weapon.

We understand that research with such different goals does not entail the same procedures. Current controversy over pedagogic methods is based partly on the inexactness of the ends pursued. If we are concerned with teaching adults, the method really matters little as long as the goal is attained. At most, some are more rapid than others. And yet slow learning

is apt to last longer. But if the acquisition of knowledge is not the only aim, and if we are also trying to mold the mind and character of a child, the very form of the exercise becomes important.

As for moral education, the two basic methods are didacticism and intuition. At one extremity, pure didacticism may consist in the dogmatic inculcation of knowledge. It exercises the memory essentially, but it may also develop courage by the extent of the effort required, as well as discipline and a sense of precision through strict fidelity to the teaching of the professor.

The intuitive method, on the contrary, strives to have the student himself discover the desired knowledge, which means that his mind must make a greater effort at research, imagination, and reflection. Didacticism demands little more than an effort to understand. It goes without saying that the use of the pure intuitive method is strictly limited. Human knowledge is the fruit of thousands of years of work by gifted minds, and left to himself the average child could discover only an infinitesimal part of what he should know.

So the process of intellectual culture can only be a combination in varied proportions of didacticism and intuition. Didacticism reigned supreme during the last centuries, particularly in the educational institutions of the Jesuits. Recent trials of the purely intuitive methods, made largely by reaction, have given foreseeably disappointing results. Therefore modern educators of the intellect have conceived, as have moral educators, the so-called active method, which, as Ferrières phrases it, is a sort of compromise "to bring out the progress in intellectual culture from the innermost psychic depths of the child in awakening his interests, arousing his initiative, and developing in him the desire to know ever more and to know it better." In brief, it is based on a desire to interest the child in what he is doing and to stimulate his voluntary participation instead of imposing the necessary effort upon him.

Is it because pedagogues are so voluble that we have had so much discussion of the active methods? Actually, the methods

rest on three essential principles, each of which is characteristic of one group of methods:

1) The introduction of concrete material into teaching to facilitate the child's understanding of things, the perquisite of the Montessori method and its derivatives. Geometric figures of various shapes and dimensions are used to convey ideas of space, musical bells for sound and noise, cloth and spools of thread of various shades to teach the colors. To teach reading and writing, the material objects are printers' letters, which the children put together to make actual texts as in the Freinet method. The Decroly method respects the child's tendency to depart from the general and end in the particular and analysis. Thus the teaching of reading by this method does not start with the letters, then the words, and finally the sentence. It starts with the sentence and ends with the individual letters. All these methods make wide use of games, which are the child's most spontaneous form of activity.

2) The assignment of tasks according to the possibilities of each child characterizes the American methods, modeled after the Dalton plan. Instead of uniform instruction based on the average level of intelligence, in which the brightest mark time while the dullest have to struggle to keep up, each child makes a veritable contract with the teacher to finish a study assignment in a given time, a contract which stimulates the child and engages his responsibility.

3) Group study, designed to initiate the child into social life. The pupils charged with a collective assignment divide the work to the best of their capacities. Sometimes one of them, older or more gifted than the rest, takes over the intra-group instruction.

Is this revolution as profound as some modern educators would have us believe? There is no doubt that the handling of concrete objects instead of looking at pictures facilitates the acquisition of basic ideas by backward children, which were Mme. Montessori's first pupils. But sooner or later normal children must acquire abstract ideas, too, if they do not arise

spontaneously. Is their conception of reality improved? As to teaching reading by the over-all approach, does it really produce a better knowledge of the language, particularly spelling? Some teachers deny this, and the proof of actual examinations does not seem to contradict them. Group study is merely the pedagogic application of the teamwork principle in games. There is in it the danger of too early specialization if the distribution of assignments is left to the pleasure of the children.

One of the motives of the active methods is the facilitation of the work of the child by using his natural inclinations. The task of the teacher is also lightened thereby. But if intellectual education is more of a shaping than a teaching, should we confirm the child in his necessarily temporary inclinations which he is bound to outgrow? Or should he be urged to acquire as early as possible the methods and concepts of an adult? In brief, should childhood be considered an end in itself?

Group studies may be truly educational if the teacher supervises the rotation of the pupils and the equalizing of assignments. But is not this intrusion in itself a resort to didacticism?

The notion of responsibility freely accepted by the child is hardly new. The old-time teachers worthy of the name appealed to this sense of duty. Besides, can the child judge his own possibilities, and should he not be obliged to surpass his own feelings? Individual work and the sense of the initiative are not excluded from authoritarian methods, for all applications of a rule learned by rote require research, initiative, and reflection. It is only by such application, moreover, that the rule can be understood.

The new methods are ostentatiously careful not to demand too much effort of a student by fiat. It is no doubt disagreeable to force children to do work that is repugnant to them. But should they not be trained in the hard law of work while they are still at a formative age, and know early that it is not man's lot to escape toil? It is a teacher's honor to demand occasional

performance of a difficult task which—because difficult—becomes profitable, even if the knowledge acquired in the process should be forgotten. The teachers that mature men remember most gratefully are the most exacting and the most unyielding in the application of a strict work discipline. Those whom children like because of their cowardly indulgence are never respected and are later remembered with contempt.

The adversaries of authoritarian education often point out that Jesuit discipline produced rebels like Descartes and Voltaire. First of all, who knows whether or not their revolt was the result of their education? In any case, their intellectual composition does honor to their educators, and it is too easy to condemn a method on the basis of a few isolated examples. How many great men have recognized how much they owe to an energetic formation which they underwent unwillingly if not with repugnance?

There is no doubt that some men have a real passion for their profession, but only after they have mastered it as a result of long effort and much will power. The initial interest, which is largely curiosity, is fleeting. It does not reappear except after much hard work. Trying to educate children by interest alone is merely to entertain them, not to shape them. School should be a preparation for life. Even when taken in the best of humor, life with its trials and struggles is not a frivolous game. And anyhow, serious culture is not acquired by amusement. School must be a serious thing, even an austere matter. It may also be dull and irksome, but should we sacrifice life for childhood, or a part of childhood for life?

The campaign against examinations and scholarship competitions is sheer calumny. If the essential mission of intellectual education is to form character, examinations make real sense, for they are tests of the will even more than of the intelligence. Nobody succeeds in a difficult examination without work. The principle may not be perfect, but when the tests are multiplied, the chance of error is small. Rare is the in-

competent who enters a teachers' training school, and still rarer the brilliant candidate who is refused. Do some candidates grow flustered and go to pieces before the examiners? They are not of the elite, since their learning fails them when they need it most.

4 ⁎ EDUCATING THE BODY

I

Consequences of Descartes' Error : Mental Effects of Physical Education : Manual Labor : Gymnastics and Sports : Comparison with Moral and Intellectual Culture

Methods of physical education throw some light on the quarrel over methods of intellectual formation. After all, man is one in body and mind, the shade of Descartes to the contrary notwithstanding. For the last two generations there has been a justifiable reaction against the Cartesian contempt for the body, a necessary about-face since civilization's tampering with the laws of natural selection is giving us a growing proportion of physical deficients. The need for physical education is the direct consequence of civilized life. The savage, the hunter and the fisherman maintain their physical activity as part of their daily lives. Only with the advent of agriculture and sedentary life did the rationalization of movements appear, and with it the need for corporal hygiene.

The Cartesian error has marked our civilization so profoundly that the general public scarcely suspects the mental

effects of bodily education. Aside from the fact that a child gets his earliest ideas by his first movements and his sensory exploration of his ambient milieu, mental activity is closely bound to physical activity. Transformation of the body has a marked effect on the psyche. Good physical balance is essential to mental balance, and experiments have shown that the mental condition of abnormal children may be improved by physical culture. The development of the senses which obviously conditions our concept of the universe derives from physical education. Beyond its practical usefulness, sensorimotor skill is a dominant factor in personality. For the average man the hand is an organ of thought as important as the brain, and it is by educating the hand that the intelligence is educated. "We know well only what we can do," and the learning of many men remains in their manual skill. So there is good reason for recent emphasis in some schools on the educational value of manual training, which teaches the child not only pride of craftsmanship, but courage and perseverance as well.

Physical culture starts with a child's natural movements and his games. In their original aspect, races, fights, even battles, were generally more efficacious than the sports derived from them. For all sports are necessarily regulated and develop different parts of the body unequally. Physical education through sport, therefore, requires close supervision. If left to the inclination of children or adolescents, it may either be insufficient or adapted to the best qualifications of the youngsters, who would thus neglect the development of their weakest points.

The natural play of children copied from that of young animals is perhaps the most complete of physical exercises. It is based essentially on chase and struggle. When limited to natural means only, it is as harmless as a tussle between two puppies of the same litter. But aside from differences in age and consequently in strength, children are always more or less tempted to break the rules and use rudimentary weapons such as sticks and stones. Play as such involves no corrective

value. Although probably sufficient for sound children, it needs to be supplemented by systematic exercise.

The nineteenth century, preoccupied with the production of soldiers, saw the rise of gymnastic apparatus for the development of muscles. Little by little it was first supplemented, then supplanted by Swedish calisthenics concerned with general posture and especially with the development of the respiratory and skeletal systems.

In reaction against the artificiality of these systems, physiologists evolved a method they called "natural," which consists of exercises conforming more closely to the natural needs of man, his protection, and his conservation. It is also designed to improve the suppleness of the neuro-muscular system through asymmetrical movements. Its basic exercises develop the muscular-motor system by walking, foot racing and jumping; the arms by climbing, weight lifting and throwing; self-defense by boxing and wrestling. And finally, all muscles are equally exercised by swimming.

The individual character of Swedish calesthenics and apparatus gymnastics did little to teach the spirit of teamwork. The natural methods gather the children into groups, from the "waves" of Hebertism to the "big games" of the British and American schools.

In all these relatively simple exercises, the intervention of the teacher is limited. He plays a major role only in corrective gymnastics or the practice of a sport. The absence of all dogmatic supervision does lead to the establishment of bad habits and bad postures, compromising progress. Riding teachers, for instance, often have better results with rank beginners than with those who have learned to ride by themselves without proper instruction. Whatever attraction sports may have at the outset, they never lead to progress without methodical work, sometimes fastidious, always indispensable. Whether education be intellectual or physical, training is usually more a chore than a relaxation.

The educative value of various sports differs widely. All

earnest practitioners may develop a sense of effort, energy, endurance, and, when they play in groups, discipline and the sense of command. Sports involving animals develop finesse and observation. However rudimentary may be the psychology of a horse, no horseman can safely neglect it, especially if he is doing any training.

Analysis of methods of body culture allows us better to judge those of moral and intellectual education. In view of the unity of mind and body, it is unlikely that principles which apply efficaciously to physical education should not also apply to the psychic. Now nobody denies that the only rational procedure in physical culture should be based on dogmatic authoritarian teaching and personal exercises. In essence, the active method with uncompromising direction. This is undoubtedly the most efficacious procedure for any education of whatever nature. It has prevailed in apprenticeship, by reason of the utilitarian character of that formative process. Is it by neglect, by softness, or by metaphysical concept that we refuse to use it in intellectual culture? When we learn to think at school by the same method we used to learn to ride a horse in the cavalry, the average man will have undergone an amazing transformation.

It is a striking fact that physical memory is much superior to psychic memory. Swimmer, skier, horseman or bicycle rider—none of them forgets the physical skills they have once learned, even after many nonpracticing years. But a language or a science is quickly forgotten. Is this because intellectual learning is less mechanized than an athletic gesture? Or because the average man tends to overstrain his psychic memory? It is not outside the realm of possibility that comparative studies will some day show us how to prolong the duration of intellectual acquisitions by multiplying certain artifices employing the various aspects of physical memory: motor, visual, auditory, even olfactory.

5 * INSTRUCTION OR INTELLECTUAL EDUCATION?

I

Elementary Instrumental Instruction : How to Learn to Read and Write : The Origin of Thought : Wealth of Vocabulary : Reading and Figuring by Automatism

The very young child relates all his contacts with the outside world to his very personal self. Later, through intellectual education, he will gradually become aware of the objectivity of things. And since he needs a guide, and must profit by the acquisition of generations of past knowledge, he must first be familiarized with the symbols and conventions which are at the base of human relationships. He will begin by learning to talk, to read, to calculate, to draw—the instrumental knowledge at the base of all culture.

While he is studying the sciences, he makes the acquaintance of man through literature, the arts, religions, and philosophy. When this general information has been achieved, he receives a professional education based on instrumental knowl-

edge which will prepare him for the practice of his life's work and his social role.

The beginning of his instrumental instruction, which arises from training, should be undertaken as soon as the mind is sufficiently developed. For example, before the age of eight, a child's receptivity is such that if he hears English, French and German spoken every day for the same period, by the time he is ten he will speak all three languages equally well, no matter which is his native tongue. Beyond this age, the learning of foreign languages becomes a laborious matter, as the deplorable output of our schools will bear witness. But rarely does a child have the opportunity of learning a foreign language in this manner at a suitable age, although nothing should stand in the way—theoretically, at least—of acquiring this knowledge in the lower primary grades.

Elementary teaching is still fundamentally reading, writing, and arithmetic. The importance of reading is more and more being underestimated. Old-fashioned teachers used to devote —and properly—most of their time and care to the subject. And why not? The ulterior culture of most if not all men is conditioned by reading. The only road to culture is through reading and more reading. There are few really personal ideas in the world. Most of what we think of as ideas are reminiscences of conversations overheard or pages read—to which we add a little bit of ourselves. This may explain why the world's great discoveries are often made simultaneously in different countries. It is the books of the masters which make us aware of what we have been thinking rather confusedly. The more great books we read, the clearer we will think. Therefore we must read, reread, copy, memorize, recite—just as the student painters copy the canvases of the old masters. But first of all we must learn to read—read with the eyes in such a way that the mind will instantly grasp the meaning of a sentence without stopping at the words. To read badly either our native tongue or a foreign language cuts us off from the mind of the author. When attention is focused on the word, the idea escapes. Many minds

cease to improve beyond the primary grades because their owners have never learned to read without effort.

And then writing. First the manual exercises which are not just a game and which like all manual exercises have a great influence on the formation of personality. But one must write well, with taste and application, in order to develop a sense of order of fine things and of work well done. One must learn (out of consideration for others) a legible signature, simply, without pretentious flourishes. One must write down thoughts, maxims, everything engraved in the receptive mind of the child.

One must write, too, to enrich the vocabulary, to copy new words and make them part of oneself. Thought is the slave of our means of expression. Learning new words enriches the thought of the adult as well as the child. The intellectual capital of a nation is invested in its language. A man's culture is revealed in the wealth of his vocabulary. True, some superficial spirits toss words to the wind, not caring where they may fall. They are using sounds, not language, and they are soon found out.

It goes without saying that knowledge of a language implies absolute respect for spelling—which yields an extra dividend in the form of discipline and politeness.

There is only one way to learn to read and write. Read, read, read some more, read aloud, intelligibly, clearly. Write, write again, and correct, revise again. This laborious method will, of course, shock more and more lecturers who would like scholastic appointments, and still more elementary school teachers. But ambition has no power to change the laws of human nature, and more and more children are learning to read and write—incorrectly. They will be cripples for life. Intellectual cripples only, fortunately, for apprenticeship will correct many bad habits. A strict overseer may reclaim them before it is too late, by fear of rejected work, for a respect for good craftsmanship.

Lessons must be read in class time. A good manual is always

superior to the bombastic verbiage of a second-rate teacher. Let the children read a fine language, or at least correct sentences. The teacher is only a competent overseer who maintains attention by changing the reader unexpectedly from time to time. Whatever it may seem, this role is far less humiliating and much more productive than to orate in bad grammar for the benefit of inattentive youngsters. But it requires character, authority, even modesty.

Once a child has acquired the reading habit, he will be able to dispense with teachers. He knows that all the world's knowledge is accessible by reading. He has acquired a taste, thanks to imposed training, for even required tasks become pleasant when they prove useful. Should he later need—or wish—documentation, he has the only efficacious method at his fingertips. However little a teacher may have stimulated a child to build a library, he has given him a taste for books and therefore for culture.

But reading and writing do not demand sufficient effort. We must also learn and retain. The little ones must memorize—not nonsensical childish recitations, but selections from the great authors, always. Simple at first, naturally. But no matter if the child does not understand everything. The less he understands at first, the more he will be driven by natural curiosity to divine, and the work will open new horizons for him. Effort alone counts. A smooth explanation is quickly forgotten. Sow obstacles, demand that each step be an attempt to understand, and the students will remember.

Memorize poetry and prose—poetry to acquire the sense of harmony, prose for vocabulary and therefore for thought. Memorize mathematical definitions for self-discipline in concision and precision. Memorize to exercise the memory, which is probably of more practical use than intelligence. Memorize to strengthen the will to effort and the faithfulness to text. No mistake must be tolerated. Nothing but perfection.

Learn to calculate by automatism, for fast reflexes are essential to the existence—even the survival—of civilized man.

When the child has learned to read, write, and calculate perfectly—and rapidly—when he has accumulated a rich vocabulary, he is ready to tackle the study of science. Not before.

Present trends in education are houses built on sand. Because time is short and the subject matter is long, hurried architects neglect the foundations and cracks appear in the splendid walls like spiderwebs, the fine façades crumble, and the tall towers totter.

II

The Study of Science : Geometry : The Inadequacy of Basic Instruction : Biology, the Super-Science, Introduction to the Statistical Character of Human Laws : The Teaching of Science

If the aim of study is character formation and not knowledge, it would seem that the subject matter *per se* would have little importance. For instance, to learn the telephone directory by heart, or the table of logarithms, is just as much a strain on the memory, perhaps more on the sense of effort, as to recite a poem or remember a mathematical definition.

But there is more than the character to be formed, for we must also acquire judgment and learn to reason. Not that intuition should be atrophied in the child in favor of logic, but we must also develop a sense of analysis which is not the exclusive prerogative of a single discipline, as mathematics, Latin and Greek are close competitors. Which explains why men of different cultures may have the same type of mind.

Although the teaching of literature and mathematics may lead to roughly the same result, the current tendency is to sacrifice letters to figures—the contrary of what used to be. The problem of culture—by which we mean education—gives way before the more pragmatical one of instruction. In other words, the importance of practical knowledge grows from day to day,

or at least it is more and more overrated to the detriment of the formative processes. In our industrial world, the man who has not at least a smattering of science is an anachronism, and the rudiments of mechanics and electricity have become instrumental knowledge almost as indispensable as reading and writing.

The study of science should begin with mathematics, continue with the physical sciences, biology, and psychology, and finish with the more or less conjectural sciences such as political economy. Knowledge always proceeds from the incoherent complex to the simple by analysis, and from the simple to the coherent complex by synthesis. We must therefore begin with the most simple sciences, which are consequently the most precise and serve as framework to the others. It is easier for an alert mind to take leave later of strict precision, or at least to grow aware of its limits, than for a mind brought up from childhood in approximation and uncertainty to acquire the method and exactness so characteristic of mathematics.

Mathematics also calls for definitions that are clear, coherent and unequivocal, independently of a certain concern for style in the quest of the simplest solution. How many problems of all kinds are badly resolved because they are badly put by people unaccustomed to the discipline of precision! And intellectual honesty is ratified irrevocably by the exactness of a solution. True, mathematics is an indispensable tool for approaching the physical sciences, as well as the engineering and biological sciences, but it would be a gross error to consider only its pragmatical ends. The man who does not cultivate the exact science *par excellence* is missing an entire aspect of life; even if he is studying law, he will be an incomplete jurist without mathematics. It is through mathematics that a child becomes aware of the universal aspiration for certainty and equity, a poignant characteristic of the human spirit. It is not by chance that the first science was astronomy, which is celestial mathematics.

Much thought has been devoted to the teaching of mathematics, and its dangers—although indisputable—must be con-

sidered in their proper proportions. Mathematics may impress a child as a sterile and artificial business. Although objects of study need not be useful in order to mould the mind, there is no reason why this science should not be introduced into games or quantitative problems of daily life, particularly elementary mathematics. Geometry is a good place to start; it is accessible and more immediately utilitarian. And the comparison of theoretical figures with real objects gives an idea of its abstraction, even its despotism.

Mathematics tends to encourage a spirit of absolutism incompatible with life. It can attack only a small number of variables simultaneously, while the smallest natural phenomenon is swarming with them. So in the mathematical study of a phenomenon, the preponderant variables must be chosen because the answer will not be valid unless the factors deemed negligible are so in reality. There is no good reason why mathematicians should persist in wanting to express living manifestations in terms of a precise equation. But the professors must realize the truth of this and repeat it endlessly.

Mathematics has also been accused of sacrificing intuition to mechanism, and therefore strangling the spirit of invention. This reproach is superficial. Solution of a mathematical problem demands as much analytical intuition as do the experimental sciences. What about geometry, which requires the highest degree of inventive spirit and calls on the mechanics of logic only to justify the imagined solution?

The layman does not generally suspect the profound knowledge of higher mathematics required by the proper practice of physics. The student is apt to think he knows more mathematics than he will ever need to conquer the laws of physics, whereas many problems of physics have never been solved because of a poverty of analysis. Recent progress in mathematics is due largely to new problems posed by our great physicists.

Physics and chemistry, which bridge the gap between mathematics and the life sciences, should give the child some

notion of determinism through the concatenation of natural phenomena. Their utilitarian character is evident, as much for the knowledge of inanimate nature as for the study of the physico-chemical phenomena which condition our lives.

As the practice of mathematics demands imperiously the assimilation of basic knowledge, nobody would think of approaching higher analysis without knowing algebra. The same wisdom does not apply in physics, where everyone wants to plunge right into the latest great discoveries without a thorough knowledge of the elementary experiments. Teaching in the technical schools too often reflects this tendency, so we get too many dangerous engineers who do not even know the working methods of physics they intend to use. First the sound foundations: the critical study and the repetition of the elementary experiments which are the basis for all sciences. And any physicist or engineer who, when seized by doubt, has never returned to meditate the very fundamentals of his science or its techniques, has never understood them very well.

But the predominant sciences are obviously the biological studies, for they are the antechamber to the sciences of man. Science, aspiring to understand the civilized world, would be in vain without the knowledge of man, which is the beginning and end of it all. Biology is the paramount science because it demands the knowledge of the elementary disciplines: mathematics, physics and chemistry. And no one can call himself a complete biologist who is not first of all a mathematician (or at least a statistician), physicist, and chemist. Perhaps the life sciences are so backward because they are jerry-built on shaky foundations.

For the adolescent, the biological sciences temper the absolutism of mathematics and the schematism of physics. By their complexity they develop ingenuity and the sense of observation. They restore man to his just place in the universe and mark the extent of his ignorance. They give the adolescent insight into the statistical character of the laws of the ani-

mate universe and therefore into what measure human and other biological phenomena may be foreseen.

The utilitarian character of the natural sciences is never dominant except in the applied schools. It is completely subordinate in secondary education. True, the "honest man" must not be too far removed from modern civilization with its saturation of applied science.

The teaching of natural sciences, like that of mathematics, initiates the adolescent into different aspects of the human mind. The sciences are only human secretions, each one corresponding to man's view of another phase of life and universe as conceived by his senses and probed by the means at his command. Man creates the universe in his own image. Just as an engineer studying a piece of machinery studies its component parts in action, so to study the human mind we must study its various manifestations—science, language, the arts.

This is why instruction should be rounded out by a history of the sciences which would convey a better understanding of the evolution of the ideas of man. The historic curriculum would also have utilitarian ends: the difficulty with which the things we take for granted today were acquired through the centuries; the evolution of theories, each corresponding to one conception of the phenomena, will give better understanding to the apprentice scholar, engineer, or physician, of the laws of which he will have to make use. He will thus perceive that scientific progress is conditioned by the precision of our apparatus of investigation and of measurement. To use a recent formula, "the scale of observation creates the phenomenon," * in the sense that the same phenomenon may take on different characteristics, according to the power of our means of research.

* Charles Eugène Guye: *Physico-chemical Evolution.*

III

The Sciences of Man : Geography and its Human Evolution : History and International Objectivity : The Social Sciences : The Literatures : The Quarrel of the Dead Languages

The habit of considering geography as a transition between the natural sciences and the so-called sciences of man would be sound if geography were really "human," in the full sense of the word. But geography too often limits itself to describing a country and the way of life of its inhabitants without the slightest scientific concern for the interaction between the two or three general laws which might derive from a study of the reciprocal action. It is, of course, true that young people should usefully learn of the diversity of human beings. But this learning would have considerably more educational value if these simple descriptions were presented as illustrations of some universal law.

Geographers of humanity, inspired by Huntington, are cautiously exploring this fertile field in America today, and have found some followers in France under the leadership of Max Sorre. This new and truly scientific concept will brighten tedious instruction that is little more than glorified Baedeker.

The old terminology, grouped under the phrase "sciences of man," encompasses the study of languages, history, literature and philosophy. Carrel and his disciples have given a much wider definition to the science of man, particularly including essential biology. The old term reflects the survival of Descartes' erroneous divorce of body and mind. As it is manifestly outdated, we are calling it in this work "the so-called sciences of man," and reserving the term "sciences of man" for use only in the sense Carrel intended it.

The teaching of languages, as we remarked earlier, should be part of the training of the very young, while the study and

analytical comparison of foreign literatures should be reserved for adolescence.

The teaching of history has been the subject of much controversy in recent years and justly so, for in all countries it is tendentious. Instead of lifting the child above the restricted viewpoint of the family environment, it merely fits him with blinkers and fills him full of disdainful, rancorous, national arrogance. Judgments differ even within the same country according to the political, social, or metaphysical ideas of the teacher. According to which author you read, the French Revolution was either an epic or a grievous tragedy which generated all subsequent disorders. As for political and military history, which occupies the biggest part of the whole, it is invariably presented to justify the national viewpoint in all circumstances. Thus the teaching of history in its present form is sterilized by the lack of objectivity and critical approach. In the absence of forgotten details, the average man is left with the conviction that he belongs to the only great people on earth, whose infallibility has never once been denied in the course of centuries.

Finding it was still too early to have an international history written by independent scholars of all countries, the League of Nations undertook to revise the classic texts to remove all that might be tendentious or offensive to other nations. A committee of educators in each country examined the history books used in other countries and asked their foreign colleagues to modify the inappropriate passages. Some progress was being made when the advent of National Socialism in Germany put a sudden end to all revision in German. How futile are all attempts at understanding between peoples if men are taught from childhood to espouse the quarrels of earlier generations! Foreign history, together with human geography in its new conception, may explain the necessary diversity of human types and the impossibility of uniformity even within the same race.

Were it less neglected, the teaching of the history of the sci-

ences, the arts, and social evolution would give youngsters a better understanding of our civilization. Modern life owes more to its artists, its scholars, its writers and its philosophers than to the great soldiers with their idealized exploits. Courage may be exalted by the example of heroes chosen from all fields and not only from among the warriors.

What shall we say about the poverty of instruction of the social sciences in France? An engineer may be graduated from one of the finest technical schools without any socio-political awareness. At best, he may have listened abstractedly with one ear to a few optional lectures on political economy. Although it may be difficult to obtain the proper degree of objectivity, such instruction is necessary in a democracy where government is everybody's business. It is bad enough that the mass of the electorate is ignorant of matters over which their votes are sovereign. At least the elite should have correct knowledge of our political systems and the economic basis of our daily life.

All big schools should round out their curricula with sociological instruction, to which the totalitarian countries devote so much tendentious effort. In the democracies, the final course should be a lesson in objectivity in regard to the regime. No social system is new to this world. All have had some sort of trial in the centuries since antiquity and have had varied success according to contemporary circumstances and the moral standards of the peoples concerned. And the classic comparison of political evolution with scientific progress is manifestly a fraud.

The adolescent should gain a synthetic knowledge of the human mind through literature, for man reveals himself, his sentiments and his reactions through his writings. The choice of sources, however, presents grave problems, for while the study of works of great psychological value is indispensable for the formation of the mind and the acquisition of knowledge, the reading of many works with which literature is en-

cumbered can only be disastrous. There is in psychology a statistical determinism more complex than biological determinism and just as indisputable. So when an author defines his characters and specifies their environment, he is no longer master of their reactions. Most authors do not bother with such considerations and make their characters act haphazardly. True, this psychological determinism admits of some exceptions, but the half-formed mind of a young reader risks being warped by random reading. It is probably for this reason that supposedly cultured city dwellers often have less sound judgment than country folk.

Need we underline the harmfulness of the trashy literature "of the heart" which poisons the minds of adolescents, especially romantic girls? The taste for reading, when it feeds on such silly nonsense, is certainly not such a good thing. We may blame the licentiousness or the stupidity of the press.

In any event, we cannot depend exclusively upon direct observation for our knowledge of life, for man moves in circles too restrained for him to learn much of the human soul from his fellows. He must have recourse to books, but the books must be by writers who are unquestionably masters—which brings up the old quarrel of the dead languages.

Certainly the study of Greek and Latin enriches the vocabulary, which is a considerable advantage in itself. Greek develops the logical sense and Latin the precision. But it is the classical authors who are the real masters. True, students can read them in the excellent translations which exist and achieve logic and precision from the sciences.

The question of the dead languages is of special concern to students pursuing scientific careers. Impartial observation of engineers shows a marked difference between those moulded by the classical humanities and those who were not. At the same technical level, the nonclassic engineers seem to have better scientific minds, but in human relationships the classics win. The classic humanities, it would seem, tend to refine an

engineer and develop his taste for analysis, possibly to the detriment of his will, for he often shows less determination in the struggle for life.

Be that as it may, most scientists do not regret the time they were able to give to the dead languages, while many eminent engineers, the product of modern education, deplore their ignorance of the humanities.

IV

The Study of Philosophy, Consummation of All Formative Processes : The Question of Religious Instruction

All intellectual education should be crowned by the study of philosophy, synthesis of all human knowledge—logic and induction, essential bases of all science; psychology and its biological bases; ethics, which is one aspect of metaphysics, seeking an explanation beyond tangible reality.

In France, philosophy is taught at an age when students have too little learning and minds insufficiently formed to benefit properly. It would be preferable that it should crown the formative period. In engineering schools the study of logic, experimental method, and psychology should terminate the study cycle. The values of the various branches of knowledge would thus be placed in proper perspective, and these human studies would prepare the student for real life, heretofore masked by the abstraction of the too exact sciences.*

But we must beware of metaphysicians. They are architects who build fine façades with little behind them, for they lack materials. A scholar may well put forth cosmic generalizations within the limits of his discipline. They deserve attention, if

* The teaching of the sciences of man, in the conception of Carrel and the author, will be discussed in the next chapter as it applies to engineers. It goes without saying that it should complete all culture. Its rudiments should even be included in primary education.

only as working hypotheses for future research. But when a man who has not spent a lifetime working with the material and psychic aspects of physics and biology elaborates a synthesis of the living and inanimate universe, the performance may be beguiling, but that is all. Moreover, the true scholar would take care not to leave himself open in such a fashion, for his whole career has taught him prudence and humility because even the accepted "truths" are not always certain.

And yet the human mind has need of synthesis. Just as a horse will refuse to walk round and round endlessly to turn a grindstone unless his eyes are blindfolded, so most men will hold back from the Great Adventure without a transcendental idea to guide them. That is why the ancient mythologies people the haunting unknown with gods and goddesses.

And this brings up the question of religious instruction.

In the present stage of science, there is still an abyss between the known—and how fragile is our knowledge!—and the transcendent. It is improbable that the gap will soon be bridged. If religion is limited to the transcendent, the fears of conflict with science are puerile. Will metaphysical cold ever be able to overcome the emotional warmth which is the base of all religious feeling? Can it ever replace the dream world and the company of saints which children love?

Furthermore, we must be most circumspect on the subject of contradictions between religious and scientific texts. For example, the phrase from the Book of Ezekiel, "The fathers have eaten sour grapes, and the children's teeth are set on edge," may seem at odds with mutationism. But recent research in nutrition and the appearance of monsters show that the behavior of both parents does influence the soma of the child.

Not only is the religious sentiment one of the deepest attributes of the human spirit and so deserves equal respect with all others if man is to develop fully, but the whole evolution of modern civilization is incomprehensible without knowledge of Christianity with which it is so thoroughly impregnated.

To deny the supernatural because it evades our means of investigation is childishness, as well as scientific treason. It is also an abuse of the credulity of simple folk who need the help of religion. For many the laws of morality will always be heteronomous, and if they may be revealed by religion, they will be better established than by abstract reasons, scientific or not. For those who will keep their faith, this total and coherent vision of the universe will be a sure source of peace and happiness. Finally, all religions practiced by civilized peoples exalt human dignity and the right for every man to be an end in himself. For this reason religions are persecuted in totalitarian states, where the individual is subservient to the community. Moreover, intolerance is incompatible with democracy, where religious instruction of all creeds should be assisted by the broader spirit of mutual understanding.

It is superfluous to destroy the legend of incompatibility of the religious and scientific spirits. There is no need to recall the names of the great scholars who were also true believers. However, the author takes the liberty of citing one example he observed personally. Although he had lived some years with Alexis Carrel, particularly toward the end of Carrel's life, he had never suspected the man's great mysticism until it was revealed after his death in the reading of his private papers. Besides, if Carrel—independently of his religious sentiments—was incontestably and visibly haunted by "the supranormal," his scientific methods never ceased to be above reproach.

6 ✳ PROFESSIONAL EDUCATION

I

The Need for Professional Education : Its Deficiency at Both Ends of the Social Scale : The Formation of Engineers

Many—if not most—men leave school when in their teens to start earning a living. For many of them, education is over. They will develop at the mercy of chance influences of their professional or social environment. The greater their financial independence, the more easily they will escape family influences.

Some will complete a good apprenticeship under the eye of an interested boss or a friendly foreman. The less lucky ones will be unskilled laborers or will learn the rudiments of some trade at which they happen to be working. Because of the fickleness of the unskilled labor market and the increasing trend toward specialization, the proportion of these unfortunates increases almost daily. In the days when an artisan took on a young apprentice, he not only became responsible to the young man's family, but for humane as well as material reasons, practically brought him up.

Industrial civilization has created the proletariat, issue of children abandoned at the intellectual and moral age of fourteen. Incapable of plying any trade other than semi-skilled labor, they live in fear of tomorrow and the obsession of unemployment. It was quite normal, therefore, for the state in industrial countries to take control of professional education as well as intellectual education. The decision is particularly logical in the democracies, where professional education is more important than higher education, for it involves the sovereign masses. But this technical education must not be allowed to fall into the error of anonymous management. It must have other preoccupations than the rapid production of skilled specialists. Although a trade may demand nothing more than the acquisition of certain reflexes and mechanized movements, professional education must be more than mere training. It must be true education, both intellectual and ethical; the profession is only the means to the end.

There is no doubt that the manual tasks imposed upon an apprentice develop his courage and other facets of his character, but he must also exercise his intellect by studies directly linked to the profession he wants to follow, and will consequently not only have a firmer grip on his skills but will understand how he fits into society. He should learn by reading, for foremen are not as good lecturers as professional teachers.

If gifted youngsters or the children of privileged social levels go from culture to a trade, then the students of technical schools should achieve at least the rudiments of culture through their trades. Technical books, happily supplemented by learned annexes, would give the conscientious student not only leadership in his profession, but a step toward liberation from the inferiority complex which is the source of so much social bitterness. Without the will to perfection, the industrial worker is a slave, for factory labor is contrary to the nature of man.

It should be noted that professional education in the democracies is most deficient at the two opposite ends of the social scale. For the unskilled laborer, it is nonexistent. For fu-

ture leaders, it is incomplete and even incoherent. This latter may be because the great democratic chiefs are not predestined and it is difficult to choose the men who should receive the education of a crown prince.

However, all engineers (to mention only one profession) should sooner or later become leaders. They will make use of men, and the success of their projects will depend more upon the quality of their personnel than of their matériel, and the way the engineer handles his juniors. During the course of his professional education, the engineer will have learned many tricks of the trade he will never use, and become familiar with many machines he will never run. There is only one tool common to all engineers, a tool which none is ever taught to use: man. And biology, genetics, nutrition, climatology, the physiology of work, psychology, education, sociology—all the studies necessary to understand what makes a man, how he should be used, and how he should be guided. The day our leaders realize this, civilization will stand some chance of being humanized.

Those members of the elite—professors, engineers, lawyers, officials—will also be the fathers. They possess the best "materials" to "make" better men. Aside from their superior heredity, they have access to better foodstuffs and can control if not direct the education of their children. Generally they are scarcely aware of the question, unconsciously imbued with the excellence of human nature, or, on the other hand, with the fatalism of psychic development. But let an artisan work metal without respecting the rules of his art, or a draftsman miscalculate the stresses of a bridge, and what a scandal ensues! This is perhaps one of the finest lunatic stories of our mechanical civilization. Voltaire was wrong when he wrote, "Genius lasts but a century, after which it must degenerate." He should have said, "Genius lasts but a century, after which it degenerates for not applying the rules of self-perpetuation."

The efficacy of vocational education necessarily varies with the nature of the trade. An apprentice blacksmith may become

an excellent workman after a few years of practical work in a forge, but an engineer will become master of his profession at a single school only in Utopia. First of all, most engineering schools dispense very generalized instruction and therefore really teach no one calling. Even if a school is specialized, it must necessarily give only theoretical instruction, for it is hard to conceive each student of engineering building a house, a bridge, or a locomotive. Only practice really teaches. So it is rather futile to specialize in higher education. So it would do no great damage to technical instruction if some courses could be dropped in favor of human teachings.

The business of leadership requires knowledge of the diverse functions of the operation, from the research offices to the final audit of accounts, by way of production and sales. Engineering schools therefore should provide some instruction, however summary, in the varied machinery of industrial organization, supplemented by a study of social and labor legislation, and supported by appropriate bibliography. Its necessary complement, a study of scientific organization of work, is largely tributary to the sciences of man. All organizers who have tried to treat the worker as a robot have failed. Those whose idealistic formulas have been based on a Utopian vision of society have fared no better. Man is a fact, with his good tendencies and bad, his needs and his aspirations. He cannot be invented, but he can be taught.

Since the great schools cannot teach a profession in detail, they should first of all form a man's character, teach him to work, prepare him to understand the men and general functioning of a major enterprise. So that purely technical schools, like the *École Polytechnique* in France, are not as absurd as they may seem to the eyes of a foreigner. But their curricula should be completed by the sciences of man and the study of the conduct of big establishments, in return for a lightening of the abstract sciences.

Some curious spirits have amused themselves in seeking a relationship between an engineer's success in life and his

standing in school. Certainly we must define success in function of criteria, either material or scientific, moral or social. In every case, the relationship has always appeared slight.

Should we be surprised that the goal pursued by these schools is not clearly defined? We do not start building a locomotive without drawing up specifications. When will our institutions of higher learning make specifications of their intellectual, character-forming, and generally human missions?

Without ridiculing the Polytechnicians in the manner of André Maurois, in *The Silence of Colonel Bramble,* who believes that "all living or inanimate beings may be defined precisely and fitted to an algebraic formula," it is incontrovertible that man can be defined and measured with some approximation on both the physical and psychic level.

Examinations postulate this fact, but almost nobody is seriously preoccupied with finding out what man should be in function of his social destination.

7 ⁎ THE SCIENCE OF EDUCATION

I

Parallel between Balanced Diet and Education : Psychic Deficiencies : Pedagogy : Systematic Experimentation : Incredible Neglect of Education in Most Countries

The parallel evoked previously between the formation of the mind and that of the body might be extended still further. Both receive from the environment "nourishment" which each absorbs to elaborate its own substance. Unconscious assimilation, which has enabled us to say, let us repeat, that the mind was formed after the instruction was forgotten, just as the adult body has lost the memory of the food consumed in youth.

Formation of the psychic personality requires various basic elements just as the body needs vitamins and plastic minerals. If we compare a rational education to a balanced diet, the indispensable psychic elements would include moral sense, logic, concepts of causality and probability—constituents which would be intellectual food in digestible form at an appropriate age. Logic, for example, may be accessible through the study of textbooks and grammar before it can become accessible through mathematics.

In function of its structure, each mind assimilates that portion of instruction which corresponds to its own character, just as the body extracts from its food those elements most suitable. And just as the body, in the absence of a complete food, should seek a diversified diet in order to avoid deficiencies, so should the mind, as long as the laws of balanced education are ignored, be taught as diversified a curriculum as possible to ensure correct formation. Specialization too early deforms the mind through hypertrophy of the favored faculties and leaving the neglected ones in a primitive state. Most warped minds are the result of intellectual bankruptcy because some time during their development they were deficient in Vitamin A or E or some psychic calcium. When the time comes that educators will admit that development of the mind is governed by scientific laws just as valid as the laws of nutrition, education will make as much progress in a few years as it has made in centuries.

Meanwhile we might restrict confusion. Why not educate from earliest childhood by a single book or set of books which will contain everything needed for harmonious development —a complete book, in a word; a sort of psychic milk? Read and reread in class, the book, or books, would be increasingly difficult and would mark out for the child the basic principles and feed his ulterior thoughts. The little peasant boy, keeping his cows or his goats after school, reflects upon his schoolbooks because he has nothing else to think about. Later he will take them home to reread.

Cannot the university have as much solicitude for the multitude of primary school children as did François de la Mothe Fénelon for his single pupil when he wrote with such joy *The Adventures of Telemachus* for the young Duke of Burgundy? Here is work for the psychologists and other educators to define the basis and composition of the perfect textbook. And more work for qualified writers to put the text into irreproachable language without the usual bleating. For backdrop there will be that purified humanity men dream about, but without

the customary puerility, for it is better to have children read pages which are too difficult than to confirm them in their childish prattle.

Our book—or books—will probably not be perfect. But, edited by the best teachers and pedagogues, they will be logically superior to the teaching of the average instructor. True, the average will have to make a certain sacrifice of his own personality to adopt our common method. But what advantages in return! Examinations would no longer be judged by the professors, but by the students. A child changing schools in mid-term would no longer be disoriented. Moreover, this written teaching—perfectible from generation to generation—would no longer disappear with the best teachers. Would we risk turning out men in series by mass production? The peril is imaginary by reason of differences in heredity, for culture, even uniform culture, diversifies men in fructifying the potential of each.

Our method might also be extended to higher education. Why shouldn't professors of special mathematics classes all use the same course as edited by the best among them? Pedagogic commentary and the applications would still leave plenty of room for the personality of the teacher.

Although it is obviously not the province of the science of education to define the ends of psychic formation, it should certainly study the effects produced on each category of students by this or that material taught in such and such a manner. There is room here for experiment, as in biology and all the other sciences of man.

The experimental method would be the following:

We would have to constitute our classes of identical subjects, that is to say two classes each having one of two identical twins, issue of the same ovum. (These twins would live in their family milieu so that all other conditions of environment, social and nutritional, would remain the same.) Then in each class we try different teaching methods and periodically subject the students to appropriate tests. Obviously the difference

in results would be valid only for the heredity and social milieu of each type of twins. But it would be an indication as to which method was most beneficial to the average child, provided, of course, that the twins were sufficiently numerous. Moreover, in applying the sampling principles employed by polls of the Gallup type, we could accord the different children various "weights" in calculating the average.

These experimental conditions are obviously difficult, if not impossible, to find. In practice we could operate in a slightly different manner to the extent that we are seeking results valid only for the average subject. For example, if we wished on a higher level to compare the efficacy of three different methods of teaching rational mechanics, we could proceed as follows: Each advancing class at the *École Polytechnique* would be divided into three parts, equal in terms of their entrance ratings, or better yet, of their rating after the first year. The first group would comprise students rated respectively first, fourth, seventh, and so forth; the next group would have the second, fifth, eighth, eleventh, and so on; and the last group would include the third, sixth, ninth, twelfth, and such. The average rating of these three undergraduate groups of sixty to eighty subjects may be considered equal. As the students are subject to the same material conditions since they are all boarding in (and the role of the professor, if he is not the same, being minimized by the use of written courses), the conditions of environment may also be considered as equal. The difference in yield among the three teaching methods would thus be apparent, if we take care to define our goal and to base results on authoritative tests given to ten or fifteen graduating classes. Such research should, among other things, oblige educators to specify the aim of their teaching and to elaborate tests which would show to what extent that goal has been attained. For in teaching, as elsewhere, problems are badly stated because—and we repeat this—the ends are not sufficiently clear.

At a lower level, it is shocking for the scientific mind to listen to the age-old debate over the respective merits of teaching

reading by classical analytical process, or by the global method, without a single argument based on exact experiment. Could we not, in several big cities, choose two series of some twenty classes each, all about equal in intelligence, and try one method on the first series and the other method on the second? Suitable tests after ten years should allow us to make useful comparisons.

But here again we must define the goal to be reached: rapidity of reading, spelling, development of character and intellectual qualities, even the lasting qualities of each method, which could be determined by testing adolescents a few years after they had left primary school.

However perfectible this line of experimentation may be, it would furnish us precious information, while all current pedagogic comparisons are made in the absence of any scientific spirit because there is reluctance to admit there may be a science of education in which pedagogy may be only a technique.

Some works on education, however, assess comparative experiments with groups of five to ten subjects. The experiments have no scientific value because of the inevitable difference between students who were not true twins. Only when performed with a very large number of students would such experiments make sense.

An automobile manufacturer who did not control his procedures by first building prototypes and comparing them after appropriate tests would be roundly condemned. Is it too much to expect that the same care and concern be applied to the formation of the mind as to the construction of machines?

Among the official inconsistencies of many countries, and of France in particular, one amazing fact stands out. The future of a nation depends upon the worth of its rising generation. Everything should be sacrificed for the physical, ethical, and intellectual formation of its children. The best men of the country should be utilized to achieve this capital aim. The career of teacher and professor should therefore be the most

highly prized, and consequently the most highly paid. True, even today there are apostles who devote themselves to such careers without thought of gain, but it is both imprudent and immoral to abuse unselfish devotion. The difficulty of recruiting for the clergy in France has shown that even religious sentiments are not enough to tempt men into a life of poverty. And what can we expect when the penury must be shared with a family?

In 1939, the author and Alexis Carrel were dining with a French scholar of great reputation and great integrity, whose research and discoveries have saved perhaps millions of human lives. The conversation had turned to the difficulty of scientific research in France and the meager pay of university professors. Carrel recalled that our guest had refused—for reasons of sheer patriotism—to accept a dazzling salary to go to the United States. In reply, the French savant concluded sadly: "I have received the highest honors that France has to offer. I have experienced greater professional joy than I had ever dreamed of. But if I had my life to live over, I would not have the right to repeat the pattern, for I could not in all conscience condemn my wife and my daughters to a life of poverty."

So the students are deserting the schools of education. More youngsters want to be engineers than teachers. And nobody in authority seems alarmed. Were a woman to take her son out of an expensive school because she needed the tuition money to keep up her costly wardrobe for the social whirl, men would cry scandal. But what seems revolting on the level of the individual seems perfectly normal collectively. Our collective sense of responsibility seems badly adulterated.

8 ✳ STATISTICAL REPORT ON THE INTELLIGENCE QUOTIENT

I

I.Q. Variations According to Background : Heredity and Variations within the Family : Gifted and Backward Children : The Leveling Influence of Environment

The foregoing considerations are all essentially qualitative. To pass from the arts to science, we must be rigid in our comparisons. We must measure. Psychologists first tried to define intelligence in terms of aptitude in solving certain problems or answering questions. Since the early work of Alfred Binet at the turn of the century, research has produced various tests which permit us to inquire into the intelligence of children of many countries and all backgrounds. These studies show that on the average, children from well-to-do and cultivated families are more gifted than those of poor and uncultured homes. The most extensive research was originally done in the Anglo-Saxon countries, particularly the United States. They show that the average intelligence quotient varies by some twenty points

between the children of men in the liberal professions and those of unskilled laborers.

American psychologists have tried to differentiate between heredity and environment as the chief reason for this gap. By comparing identical twins, separated since infancy, with adopted children, they concluded that among children with the same heredity and in the same social level the I.Q. difference due to environment is about ten points. This also leads to the conclusion that the average difference due to heredity would be another ten points between children of laborers and those of the wealthier families. This result is due partly to the fact that the intelligence level of couples decreases regularly with the social stratum. That is to say, if a child from a well-to-do family were raised by a manual laborer, he would have an I.Q. ten points lower. And a child from an underprivileged family would overcome his ten-point handicap due to heredity were he raised by a professional man.

We have been speaking only of the averages of all children of a given milieu, but there are important variations of intelligence between children of the same family. Study of the influence of the order of birth has given contradictory results. It is possible that the average intelligence at birth may vary inversely with the age of the mother, but in a favorable environment this is probably overcome by the greater experience of family educators, so that at the age when the I.Q. is measured, there has been compensation.

On the other hand, it has been well established that the average intelligence decreases when the number of children increases. This is probably due to many factors at work simultaneously. First of these is the lesser fertility of the upper-bracket families who wish to better their children's chances in life by limiting their number. Second, the children of large families are often born at too close intervals, which is harmful to their prenatal formation. And finally, the parents of large families have less time to devote to each child. Perhaps the lower I.Q. may even be due to the relatively low intellectual

level of conversation in a family where there is always a very small child.

In any event, the decrease of the I.Q. with the increase in number of children would not be inevitable if the births could be suitably spaced, the parents able to devote enough time to the education of each child, and the youngest trained to listen in silence. But the decrease does exist statistically, and this is of considerable social importance.

But whatever the influence of order of birth and the size of the family, the practical differences between children taken at random seem to derive from internal differences within the same family. In interpreting the work of Barbara Burks, we may find a difference of as much as thirty points between the I.Q. of brother and sister. Thus we may expect to find mediocre children in the upper echelons and gifted children in families with meager intellectual backgrounds. So according to this inquiry the social level, however important, is not the determining factor, since variations within the same family may compensate for the influence of origin and social environment.

It would be inexact, however, to attribute these last-named differences to Mendelian factors alone, for the prenatal milieu may have been profoundly different in the course of successive pregnancies. The differences may have been in terms of the mother's health, her diet, medication taken, and the physical and psychic climate to which she was exposed. Comparison of pseudo-twins and ordinary brothers confirms the important influence of this prenatal environment, scientifically proved by recent studies of teratology.

In brief, we may sum up these American and recent French works by saying that, on the average, for children from good families enjoying a good social and intellectual milieu, the I.Q. should vary from 125 to 95, while children from less privileged families will show a variation of from 105 to 75.

Idiots and imbeciles have an I.Q. of less than 50. Between 50 and 70 lie the backward children. Children above 130 are

considered very gifted, above 140 exceptional. The two extremes of the statistical scale, the idiots and the very gifted, may appear in any environment.

These statistical conclusions are of great interest yet they call for the following remarks:

All the above studies involve children, and the intellectual differences may change during growth, although Robert Woodworth's studies on twins indicate that the differences are maintained about the same for each. The better diet of the wealthier levels of a society certainly hastens the fruition of intellectual gifts, just as it advances the advent of puberty by several months to several years. It is possible that this handicap of the less-privileged levels may turn to the advantage of their children if we believe that the slowness of man's formation is one cause of his superiority over other creatures. There are plenty of examples of children who were brilliant in the lower grades and who were surpassed later by children from more modest backgrounds who came more tardily to fruition.

Furthermore, these results are valid for North America and there is no doubt that they are linked to the American social order. In the present state of affairs, if the children from all backgrounds had equal material possibility of following the same studies, the stratification would really correspond to the value of the individual, and difference in the intellectual level between the adults of the governing classes and those of the most underprivileged would be at its maximum.

The homogeneity of the social levels thus stratified in terms of intelligence would reinforce the differences still more. The research of American psychologists has also proved that the average level of a group of children has a great influence on the evolution of the intelligence of both the gifted and the retarded. A sort of leveling off occurs, by which the more intelligent lose and the less bright gain, which poses the whole problem of educating superior children and strengthens interest in the Dalton plan. What is more, this phenomenon is found in all adult societies. Many an exceptional man has had

his superior qualities blunted by being forced by events to live in an inferior milieu, just as many a mediocre child has acquired wit and finesse by contact with the elite. But to rate the average of a group, we must take into account individual temperament, for some men of character, good or bad, have more influence than others over their fellows. As Maeterlinck has noted in his *Wisdom and Destiny*, the very presence of the wise dispels tragedy and shameful thoughts.

II

The Philosophic Problem of Eugenics : Social Stratification by Intelligence : Experiments on Dogs

Every man endowed with physical and intellectual qualities must be aware that he is the possessor of the soundest of riches, since they can be passed on to posterity without fear of inheritance tax or finagling executors. On this basis certain thinkers have lauded eugenics to the extent even of recommending that gifted men should mate only with women of equal talents in order that the integrity of their gifts be not compromised. Would this selection, which would only accentuate the differences between men, be wise? For while we may well artificially eliminate inferior lines in domestic animals, the same thing is unthinkable in human terms. Must we seek genius at the risk of keeping less gifted beings at the bottom of the social scale? It seems that nothing would be wasted. We must decide if it is better to strive for a homogeneous humanity of average level, or for an exceptional elite to the detriment of the majority. The question is not yet within the province of science, but rather that of philosophy and sociology, for the choice would be to determine which would be of greater benefit to humanity—raising the standard of the majority, or increasing the pace of progress.

Whichever is the answer, there is no doubt that the milieu may be greatly improved, even in the most favored families. Methods of education are certainly still perfectible. Nutrition still more, for even if the wealthy eat better, the feeding of children is still defective in nature and generally by its excess, too. Besides, there is much to be done in the matter of climate. Many children of the well-to-do are weakened by the debilitating climate of cities, hardly propitious for the development of courage and energy.

It is obviously hard to say how much improving the milieu of the most-favored classes, materially and intellectually, would affect the average intelligence quotient of the children. It does not seem excessive to predict that the I.Q. average could be raised fifteen points if not more, taking into account the prenatal environments.

But we must put the question more precisely.

Obviously the most defective milieu is, on the whole, that of the "wild children," raised by animals—of which we spoke earlier—even though their diet is more natural than that of civilized children.

Let us consider two families:

One—the less favored—is a family of unskilled laborers. Their diet is barely sufficient in quantity and definitely deficient in quality. They are badly housed in dark and dreary premises, with only one room heated in winter. Since the whole family must congregate there during cold weather, conversation among adults is practically impossible because of the noise the children make. Reading is confined to one newspaper, more or less tendentious. For amusement there is the television set and its too often stupid programs. The child's companions are those of the gutter and the classroom, at random. The psychic climate is marked by material difficulties and the uncertainty of tomorrow. The parents are not always on the best of terms. The mother plies her tiring trade of housewife even during her pregnancies, and has barely enough to eat

of cheap food which contains few protective or constructive elements.

The other family is that of a wealthy man in the liberal professions. He voluntarily eschews luxury but he has no material worries. Their diet is rational. The children have a quiet room of their own in which to do their homework, and the parents supervise their studies. The rooms are well lighted and correctly heated. The children take regular and frequent fresh-air outings, even in cold weather. They also travel. The parents get along well. At mealtime the talk is of serious things and ethical questions. The children listen, authorized to speak only to ask pertinent questions. The parents choose books for the children to read according to their age and orient their tastes. The atmosphere is one of calm. During her pregnancy, the mother enjoys good health, is correctly nourished, and avoids fatigue.

The same eggs—since we must go back to the instant of conception—honestly endowed and placed in these two extreme conditions, would produce children who, at the age of fourteen, would differ in I.Q. by twenty-five points between families. In the first the average child would have an I.Q. of about 95, or slightly below the norm. In the second he would reach about 120—well above average although not particularly talented.

Intellectual differences between social levels could thus become much more important than those previously indicated for the United States. Extreme differences could obviously be attenuated to the advantages of the lower strata by improving their milieu, but it is evident that this reform would be more laborious than for the upper strata, largely because of lesser parental understanding and the paucity of their material means.

Be that as it may, improved selection and environment benefitting the governing classes in such countries as France and the United States would lead, as far as we know now, to an inferior class making up 10% of the population with children

having an I.Q. of between 75 and 85. As we may stipulate that children who now score 125 already possess a good—if perfectible—environment, we may estimate their supplementary gain at another ten points. So that the upper social strata—another 10% of the population—would produce children with an I.Q. measuring up to somewhere between 130 and 140.

These are of course only indicative extrapolations. Only repeated and methodical experiment could yield truly valid results. And we would have to differentiate quantitatively and precisely between the influence of the various factors: nutrition, climate, psychic milieu, and even the elements of which they are composed. The French Foundation for the Study of Human Problems once proposed to conduct just such an analysis according to the ideas of Carrel. A large number of thoroughbred dogs were to have been selected for their intelligence and crossbred with brothers and sisters for several generations, so that we would finally have a number of dogs of practically identical hereditary patrimony.

The different environments would have been systematically modified to measure the influence of each of the variables. Of course, we would have had to define the intelligence of the dogs and the criteria adopted. The extrapolation from canines to man is obviously not without risk, but beside the difficulty of experimenting with precision on human subjects, the canine method would have permitted rapid conclusions, for dogs are adult at the age of one year. Further experiments might have been conducted with animals reputed to be even more intelligent than dogs, such as the raccoon.

III

Intellectual Values in Relation to Environment, Racial Origin, and Size of Families : Order of Birth : Research in France

From the very first application of tests to evaluate intelligence, Binet himself and Mme. Thévenot in Paris, Mlle. Degand in Brussels, and Miss K. Johnson in England have noted systematic differences of the I.Q. between social classes. Using the Binet-Simon scale, Morle compared the children in two schools classified according to the parents' income, and concluded, as long ago as 1910, that "the inequality of poor children and well-to-do children increases with age. Family influences play a major role in the intellectual development of the child, either through superior diet and hygiene or by better milieu and example." *

Cyril Burt has since sought to determine whether the difference was due to heredity or to environment alone. After profound study he concluded that "parental intelligence may be inherited, individual intelligence measured, and general intelligence analyzed, and the three may be analyzed, measured and inherited to a degree that few psychologists have until now dared claim legitimately."

In 1913, J. and R. Weintrob, as well as Strong, studied the influence of racial origins of Americans. They found white children distinctly superior to Negro children, and city children more favored than country children.

In 1930, Otto Klineberg, studying rural, urban, national and racial factors, compared ten groups of European children, each

* Much of the documentation given here is drawn from Chapter VIII of *L'Eugénique* by Dr. Jean Sutter, one of the organizers of the French Foundation for the Study of Human Problems, a dear and esteemed friend of Alexis Carrel. The work was published in 1950 by the Presses Universitaires de France for the National Institute of Demographic Studies.

made up of one hundred boys from ten to twelve years old. Three groups were urban (Paris, Hamburg and Rome); seven were rural (North Germany, Alpine Germany, French Flanders, Central France, Southwestern France, Italian Piedmont, and Sicily). The intelligence of the groups was rated as follows: Paris, Hamburg, Rome, North Germany, Mediterranean France, Alpine Germany, Piedmont, Central France, French Flanders, Sicily.

The greatest differences seem to be between cities and country. Racial differences are not significant. The difference between city dwellers and rural folk of the same country is much greater than that between men of the same habitat in the three countries. Environment thus seems to play a greater role than race.

Most researchers agree that there is a negative correlation between the I.Q. and the size of the family; the larger the family, the lower the I.Q. The studies of L. M. Terman, Chapman and Wiggings on some thousand individuals in the United States, those of Arthur Sutherland and Thomas on two thousand British children, those of A. D. Roberts, also in England, and those of Heinen covering nearly four thousand school children in Germany, add up to a correlation coefficient of about —0.22. The conclusions may be diagramed as follows:

Number of children in family	1	2	3	4	5	6	7	8	9
Average I.Q. of brothers and sisters	117	118	114	108	106	106	105	103	98

In 1939, Kuribagasi demonstrated in Japan that the I.Q. decreased with the order of birth and even more rapidly as the age of the parents increased. According to the following table by Henri Pieron, which gives the I.Q. of the children in relation to the age of the mother at birth, it would appear that the most favorable age for a woman to conceive would be between 21 and 25:

Age of mother	16-20	21-25	26-30	31-35	36-40	41-45	46-50	51-55
Number of children tested	404	2,537	2,507	1,768	1,198	465	78	15
Average I.Q.	107.0	107.3	106.4	103.5	100.2	101.8	92.1	78.1

These conclusions should not be adopted without some reserve. Some researchers, particularly Jones and Grace Arthur, find no difference in the I.Q. in terms of the order of birth when the sampling is correct; they even find a slight superiority of the youngest over their elders. The question obviously calls for further research.

The respective influence of heredity and environment has been studied by comparing adopted children and by comparing identical twins separated since birth. The first method presupposes that, including a sufficiently large number of children adopted at random, the average heredity would remain the same, from one adoption environment to another. Thus average intelligence differences would be due solely to environment.

The identical twins method, unfortunately limited to a restricted number of experiments, shows an average difference of about six points in I.Q., proving the superiority of one environment over one less favorable. This leads Frank Freeman to conclude that human nature may be improved or deteriorated by education to a degree many have believed impossible.

Study of adopted children amplifies this conclusion. The following figures are based on experiments with illegitimate children of comparable heredity:

45 children adopted into good family environment had an average I.Q. of 112.

39 adopted into a fair family environment had an average I.Q. of 105.

27 adopted into a poor family environment had an average I.Q. of 96.

The following table by Burks shows the correlation coefficient between a child's I.Q. and the principal variables of the environment:

	Correlation Coefficient of I.Q.s	
ENVIRONMENTAL CHARACTERISTICS	ADOPTED CHILDREN	TRUE CHILDREN
Father's I.Q.	0.09	0.55
Mother's I.Q.	0.23	0.57
Material advantages of the home	0.24	0.48
Cultural advantages of the home	0.29	0.49
Income	0.26	0.26

The correlation between the I.Q. of the parents and that of the children is evidently greater for true children, but the table is particularly informative in showing that the mother's intelligence is a greater educational factor than that of the father, and that the influence of the material and cultural advantages of the home is much more marked in the case of the true children. This leads us to believe that parents have more effect on the development of their own children than on that of the children of strangers.

In 1933, Outhit found that the correlation between the average intelligence of the parents and that of the children was about +0.80. The correlation between one parent's I.Q. and that of any one of his children is about +0.50. Outhit also found a correlation of 0.74 between husband and wife of the many married couples he studied—which indicates that humans generally do not marry at random but are apt to choose an intellectual equal.

Researchers are generally agreed that heredity and environment play equal parts. Yet statistical spreads show that the differences within the same family are greater than the average differences between one family and another.

According to statistics, especially gifted children may appear in any social level, but are more apt to appear in the upper strata. Researchers estimate that 31% come from the liberal professions, 50% from the semiliberal professions and

the business world, 12% from skilled workers and 7% from unskilled workers.

Research started by the French Foundation for the Study of Human Problems in 1942 has been carried on by the National Institute of Demographic Studies, which published its results in 1950: *Le Niveau Intellectual des Enfant d'Age Scolaire* (Presses Universitaires de France), which was the work of Prof. and Mme. Henri Pieron, Dr. Jean Sutter, and others. The project is an important contribution to the social sciences.

The work was carried out with tests especially devised for the project, including Gille's "mosaic test," upon pupils of both private and public schools in France. Its essential conclusions were these:

Sex as such has little influence on intelligence. Girls seem to have an edge over boys until the age of nine, when the masculine superiority develops.

Residence and social environment introduce important variations. The most favorable results were obtained by children whose fathers' profession was the following (in ascending order): farmer, rural worker, city workers, rural clerks and government workers, city clerks and government workers, industrialists and merchants, intellectual and liberal professionals.

The experiments confirmed the theory that intelligence varies inversely with the size of the family, although the difference between an only child and a family with two children is slight. The importance of the family influence seems to be a function of environment. The unfavorable influence of many children, quite marked among farmers, workers and white-collar people, is much less felt in the intellectual professions and liberal arts.

IV

The Loss of Psychic Freedom : Possibility of Artificial Human Mutations : The Superman : The Era of Made-to-order Men : Guide to the Rational Manufacture of Humans

We must still define the limits of optimum natural conditions for the development of the individual. To the general anxiety produced by the improvement of means of destruction has been added, particularly in intellectual circles, an anxiety of a higher order.

Recent progress in physiology has confirmed the fact that the psyche may be influenced by chemical substances, particularly the hormones. Aside from its morphological characteristics, the behavior of a man may be completely changed by appropriate injections of glandular secretions or their synthetic equivalents. We could, as a result, become "spiritual robots" in the hands of an informed physiologist. Free will and responsibility would be nothing but illusions. Spiritual concepts and the whole ancestral scaffolding of our beliefs would crumble before this rape of the human personality.

Until now thought has always appeared to be the supreme refuge of freedom. For although the body may have been chained, the spirit has always remained free. And now that, too, seems to be accessible. But have we not been heading in this direction for a long time? Not only may the psyche be assaulted by the written or spoken word, but it may also be altered by artificial nourishment or degrading living conditions.

Modern man is already an artificial creature, more and more disturbed and tormented as his life becomes more arbitrary. And the precariousness of his philosophic and social concepts is the measure of his instability. True, these changes in personality are involuntary and cannot as yet be provoked deliberately. But even if they could be, the anxiety aroused by the risk of profaning the soul seems rather premature in view of our traditional concepts of humanity.

Is it because a creature can indeed be chained that he must doubt the existence of physical liberty in normal man? And this normal man, as our ancestors have conceived him, is inseparable from a fixed milieu. If a man who has been physically mutilated is no longer a man in the strict sense of the word, why is the human being whose natural psyche has been artificially disturbed still worthy of the name?

Moreover, the normal man is neither a figment of the imagination nor the product of chance, since nature tends to return the living creature to his normal *habitus*. The processes of copulation and natural selection erase exceptional beings by regression toward the mean, while sexual attraction, by its tropism to the healthy and handsome, tends to revive the original type. The more life is natural, the closer man approaches the standard justifying our beliefs in human dignity and responsibility. It would appear that there is a sort of harmony between normal conditions and the average man who seems to be the symbol of stability in the present state of affairs, since it is he who tends to take the upper hand.

That the average man is in danger of being violated by new physiological techniques is certain. But can he not be protected psychically by society, just as he is protected physically, since the attack on his mind would be accomplished by physical processes?

Another equally recent preoccupation concerns the possibility of eliciting within ourselves the appearance of a superior race. Although all work to date is concerned essentially with modification of the soma, it is not inconceivable that man may some day succeed in altering the germ cell itself.

True, some mutations become permanent, but those known so far are always regressive. Does this mean that a new and happy mutation is impossible because if the potentiality existed in man it would already have appeared? The reply to this question is obviously impossible. We do know that experiments with domesticated animals have shown that man has been unable to create mutations that are naturally viable. For when

such animals are freed in their natural habitat, they return to their wild ancestral type in a few generations. The spectacular mutations of albinism in rabbits and drooping ears in hogs, for instance, quickly disappear in the state of nature. It goes without saying that the disgrace of obesity, a purely somatic modification, does not exist under normal conditions.

On the other hand, there are mutations in insects that have supplanted the type. Thus the light-winged birch moth disappeared in England about 1850 and became a mutant with darker wings. Whether this mutation was due to the transformation of environment by industrial establishments, or whether it was spontaneous—that is, due to undiscovered causes—we do not know.

If a mutation in man caused by artificial modification of his environment needs the same environment to perpetuate itself, its continuation is obviously precarious. But it is not impossible that man may hasten, consciously or not, the appearance of a viable human mutant under normal conditions of milieu. The first results would doubtless be disappointing, as previous interference has yielded nothing but unfortunate monsters. But it is conceivable that one of these monsters, regardless of the horror he may inspire, may manage to multiply, to dominate the normal type, even to supplant him completely.

This superman, biologically superior on the whole but not necessarily in detail, would he, too, torture himself because he was not bigger and better—like the normal man? We cannot help thinking, in this respect, of those engineers who keep inventing new things without end until they finally bring down the whole business on their own heads. But if savants had never gone on searching for the sheer joy of the search, without worrying about the distant and unforeseeable consequences of their discoveries, science would never have existed. And it is up to philosophy to rejoice in this fact—or to deplore it.

While awaiting the advent of superman, the hallucinatory *Brave New World* by Aldous Huxley casts a vexatious suspi-

cion on all techniques for the improvement or restoration of man. The manufacture of mortals in homogeneous series as described by Huxley is perhaps more shocking by its abolition of natural fecundation and gestation than by its other inhuman characteristics. The rest, particularly the nutritional, climatic and educational conditioning of the embryo and later the child for the better realization of his talents, are realizable by natural means. They represent rather a return to natural conditions than a resort to the deliberately distressing artifices of the British author.

There remains the choice of heredity. First of all, eugenics is not a recent invention. Eugenics has been practiced since time immemorial and Plato himself extolled its virtues. Only we have learned how to manage it better since we began to know the laws of probability governing the transmission of both physical and intellectual characteristics. So it is obviously only a short step now to the point at which an authoritarian regime, submerging the individual to the interests of the masses, could force a male mathematician to copulate with a female mathematician because the government was short of accountants.

And we may even imagine a future *Guide to the Rational Manufacture of Humans* with a chapter entitled "Physicists" giving the following formula:

> Order from the human stud cold-storage plant at P——ville male spermatozoa No. 2980 or No. 3421* (Consult Catalogue of Spermatozoa for characteristics).†

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* The separation of *y*-chromosome male spermatozoa from *x*-chromosome female spermatozoa was achieved in 1995 by perfecting the electrical methods of the Soviet scientists Koltzoff and Schrader.

† Spermatozoa 2980 issuing from the English physicist Jude H., died 2051, height 1 meter 72, black hair, black eyes, I.Q. 182 (physics gradation). No. 3421 issuing from Parisian physicist Jean L., died 2082, height 1 meter 75, blond hair, blue eyes, I.Q. 171 (physics gradation)—Editor.

During the month of May or June‡ fecundate a young woman between the ages of 23 and 28. She should be a graduate cum laude from the Higher Normal School or have a fellowship in physics (Minimum I.Q. 150,§ physics gradation). During the year previous to conception, she should be fed on the special balanced diet designed to prepare intellectuals for maternity, but should continue her laboratory work during the whole period. (See chapter on "Nutrition," subheading "Pre-conception.")

During gestation, the dosage of physical culture and scientific reading should be increased and rest periods in the natural reserves of the Massif Central should be multiplied. Special balanced diet for pregnant intellectuals should be administered. (See "Nutrition," subheading "Gestation" for proportions and quantities according to the measurements of father and mother.)

During breast feeding, the mother shall receive the special balanced diet for nursing intellectuals. Later the child shall be given the special forcing diet for intellectuals according to his size. (See "Nutrition.")

CLIMATE

The child shall be raised in a natural reserve with a not-too-stimulating climate (such as Reserve No. 5 in the Alps) until he is 15. From 15 to 20 he shall be moved progressively through five distinct climates, slightly more stimulating (such as Type No. 7, the Vosges or the Massif Central). After 20 he shall be placed in No. 10, special stimulating climate for intellectuals.

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‡ The influence of the month of conception was determined early in the twenty-first century. As far back as 1935 this discovery was to some extent foreshadowed by statistics published in the United States of America by Ellsworth Huntington in his work *Season of Birth,* to the great surprise of his contemporaries who naïvely believed that children, like automobiles, could be manufactured with equal efficacy at any time of year—Editor.

§ The idea of the intelligence quotient has undergone considerable evolution since its creation at the beginning of the twentieth century. In its present sense, dating from the year 2000, the expression denotes the intellectual value in a given field of a man at the height of his intelligence, age in general about thirty-five, compared to that of the average man of the same age—Editor.

SPORTS

All sports of natural character or mechanical work shall be performed exclusively by human motive power in order not to conceal the laws of nature by artifice.

STUDIES

Dead languages: Greek and Latin (for precision and logic). French (direction of effort).

Sciences: Mathematics and geometry (complement of precision, imagination); biology and some science of man.

Physics: a) If the physicist is destined for technology, he should study physics at the age of 16 along with other disciplines; b) if he is destined to do original research in a given field, he must be forbidden all contact with current concepts of this branch of physics until he reaches the age of 25.

PROBABLE ADULT CHARACTERISTICS

a) With spermatozoa 2980, black or brown eyes, dark hair.

b) With spermatozoa 3421, blue or brown eyes, fair or chestnut hair, depending upon the mother.

Consult statistical tables for probable height as determined by figures for mother and father. The I.Q., physics gradation, may also be determined approximately by consulting the statistical tables appropriate to the parental levels. The same tables will indicate the probability of obtaining a higher I.Q. than the required minimum. In order to insure this probability, the operation should be repeated a sufficient number of times. The same mother may serve twice with a minimum interval of three and one-half years between impregnations.

After the age which we call that of *Homo sapiens,* we will see the Age of Made-to-order Man—unless in the meantime some uncontrolled chain reaction should effectively remove the earth from the universe, blowing to smithereens the apprentice sorcerer and his mad dreams.

And the distant planetary systems will pursue their appointed rounds with magnificent unconcern.

9 CONCLUSION

I

Science and Ethics : The Impossibility for Science to Define Moral Ends : The Responsibility of the Elite in the Future of Civilization

Before concluding, we must return to the anxiety mentioned in the introduction—anxiety over the future of humanity, provoked by the disparity between the growth of material means, especially the means of destruction, and the evolution of our moral level. This alarm may seem surprising in view of classic philosophy's assertion that there is a certain affinity between the development of science and that of ethics.

Aside from Leonardo da Vinci, Pascal, Rousseau, and Kant, most thinkers are agreed on praising the happy repercussions of science on morality. The eighteenth-century philosophers in particular have insisted on the parallelism between learning and the formation of moral sense.* This primordial ques-

* ". . . by a happy choice of the branches of learning and of the methods of teaching them, the entire mass of a people may be taught all that any man need know to . . . escape from the prestige of the charlatanism

tion deserves to be reviewed in the light of the social balance sheet of the nineteenth century and the first half of the twentieth century. First of all, when we are speaking of human behavior, we should recognize our ends and spiritual data, that is to say we need a clear view of the goal to be attained as well as the talents and material means required to reach it. Do not philosophic divergences rest essentially on a confusion of these various elements?

First of all, can science define and enrich moral ends? Certainly not in our present state of knowledge. If all ethics derived from scientific theories seem to collapse one after the other, it is because only a complete knowledge of the nature of man and his destiny would permit the elaboration of a valid morality, which now remains in the realm of intuition or, as Rousseau would say, of divine instinct. Certainly, philosophers periodically announce that they have elaborated a definitive synthesis of the universe from which they can deduce a basic code of ethics. But human indigence, of which we are becoming more and more aware, no longer permits us to give credence to these illusions, not because we are skeptical but because we are prudent.

As for spiritual powers, can we reasonably affirm that there is a parallel between the development of the mind and that of the moral sense? When the intelligence is not formed according to a strict discipline, it is difficult to ascertain how the subject could acquire the qualities which are basic to the principal virtues: sincerity, courage, honesty, exactitude, and a striving for perfection. On the other hand, observation of men who have been through a strict formative period allows us to state that, statistically, moral values develop jointly with the scientific mind, and that those whose last years of adolescence have been given seriously to the sciences are generally

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which would trap his fortune, his health, and his freedom of thought and opinion under pretext of enriching him, healing him, and saving him."—Marquis de Condorcet, *Esquisse d'un Tableau Historique des Progrès de l'Esprit Humain* (1794).

ethically superior to the others. Perhaps this is because it is difficult to have two sets of behavior—one of intellectual honesty in study, the other a compromise with truth in social life. Probably this is why, in industry, we find a more and more marked divorce between the technical elements and some of the commercial services: excellent engineers have a bad time in business, where sales talk too often takes liberties with the truth.

Assuredly, as we stressed in regard to education, we must differentiate between the formative values of the various sciences. Although all of them seek the truth, some like mathematics and physics do so with exactness, while political economy and philosophy are only approximative and consequently cannot provide the mind with as rigid an ethical framework. On the other hand, oriented more toward the human side, they can protect against a certain stiffness and intransigence sometimes typical of engineers in their social relationships.

Most reproaches that the scientific world suffers from lack of modesty must be considered venal in character. The supposed conceit of savants is more often simple vanity, sometimes senile, induced by the intoxication of flattery, rather than true conceit. Scientists worthy of the name are aware of their own ignorance and the limitations of their powers. And with rare exceptions, they do not turn their discoveries against humanity. Very often they are frightened by the use that may be made of their work. Recalling the attitude of Leonardo da Vinci, who scrupulously refused to reveal the manner he had discovered "for traveling under water," some atomic researchers tried to detour the American government away from using the atom for warlike purposes. Neither can science be accused as a method of dominating, enslaving or exploiting mankind, for savants and inventors rarely profit by their own discoveries, either by disinterest or by candor, for as Bergson says, "The slope that leads from curiosity to credulity is slippery indeed."

But the basic problem is to know if science is capable of enlightening or confirming the aim of ethics and can furnish

material means of pursuing it. Skipping lightly over the cruelty of application which dishonors science, we may ask whether science can discern the opportunity of using its own discoveries for ethical ends. To answer this we must be aware of all possible consequences, near and far.

The inventors of white bread did not suspect that they were bucking biological law and undermining the health of their consumers. Who knows whether exaggerated mechanization does not disturb the free physical development of man, or whether traveling by automobile rather than on foot or flying faster than the speed of sound is within the nature of man? In the same way vaccinations, now in favor with most of the medical world, may ultimately turn out to be detrimental to the future of the race by upsetting the biological balance in nature. In all truth, science and technology do not usually worry about the consequences to humanity of their work. And as Carrel has pointed out, it is in this that they have unwittingly betrayed their origins and their supreme ends, even compromising their very perpetuity.

Once aware of the danger, science obviously could illuminate ethics when a sufficiently lengthy period of experiment has revealed the harm to humanity of certain of its ideas or discoveries. Science can also justify moral rules that are older than science, dating back to a time when there was only instinct or confused observation instead of science. For example, although genetics has only recently explained the perils of consanguinity, unions between near relatives have been taboo for thousands of years. By destroying superstition and increasing nutritive resources, science has also aided morality, at least in its rudimentary stages.

But it could help even more if by changing objectives science could restore man to his priority. Perhaps this new road would lead science to slow down the pace of disorderly development in some branches, or at least in the application of science. And this philosophical quarrel between savants was the basis of the hostility of some scientists to Carrel. Since the

death of Carrel, the author has been able to contemplate with more serenity the epistolary quibbling between Carrel and some members of the Academy now deceased. And he is convinced that man-to-man personal contacts would have dissipated the misunderstanding, or at least raised it to a philosophic level.

In any event, science can certainly discern the ways of life —nutritional, climatic, and psychic—capable of amplifying the moral qualities. Science may also apply strict scientific methods—or at least statistical methods—to the study of those psychic techniques most suitable for developing the moral sense. And the intrusion of scholars trained in precise disciplines into the moral sciences can only improve their precision, although like pedagogy, some are essentially still more arts than sciences.

Although we may then grant to philosophers and educators that the moral qualities may be indirectly developed by scientific practices, we must frankly admit that if science is incapable of defining moral ends or even generally justifying spiritually the new means placed at the disposition of man, it may by changing objectives bring effective cooperation to ethics. And the total distrust by Pascal of intelligence, philosophy and the sciences, aggravated by the phrase of Socrates' moralist surveying the discoveries, "How many things of which I have no need!" cannot be justified in regard to the material sciences. True, the Scriptures as well as Kant make a virtue of the lot of the humble. But can this freshness of soul, although compatible with culture, stand up statistically against contact with civilized life? In any event, simple souls are easy dupes. It is at this point that society intervenes and inserts danger into the drama, for the means developed by science may become deadly weapons in the hands of the rulers. It was to lessen this danger, among others, that Carrel would have no state decide upon important matters without consulting a committee of sages, aware of scientific and human problems involved, who would weigh the immediate and long-

range consequences of each project. This precaution seems unhappily nowhere near adoption in the immediate future.

The essential question, therefore, is the choice of a design for society and especially of its leaders. Aside from enlightened despotism, an illusion conjured up by the philosophers of the eighteenth century, history has shown that there is no ideal solution. All regimes have known good shepherds and bad, whether the bad ones have held power through the favor of a prince or through the ignorance and artlessness of the sovereign people.

A mandarinate would perhaps be one of the less hateful forms, provided the beneficiaries were properly brought up and subjected to a scientific education balanced by human studies and experience. This selection would furnish only the cadres for the nation, as the higher posts would be filled by a choice in which the mass of the electorate would intervene more and more, directly or indirectly. Whatever the arguments in favor of universal suffrage as we have known it, the evolution of civilization has outgrown it. In primitive societies it was perhaps a guarantee of order, where physical vigor was equally divided among all classes and where in case of differences, the majority could impose its will by sheer weight of fists. But the advent of technology has upset this statistical balance, while science confirms the fact that psychic equality is a simple-minded concept. If, equitably, all men should participate in the destiny of their country, the equality of votes is an error of standards which weighs heavily upon the fate of the democracies. True, the criterion for calibrating an electorate into one-, two-, or three-vote categories is a delicate one, and the dangers of the scaled vote are well known. But lazy or facile solutions never pay off.

Be that as it may, our most urgent task is to improve the ensemble of the population. We agree with Alain that this necessity is more pressing than molding superior men, as Carrel believed, capable of coping with the problems born of progress.

The material conquests to which our most talented men now devote themselves are only secondary, for the future of our civilization depends more on the moral values of individuals than on the extent of our technology. Man has been sidetracked from essential problems by the intoxicating temptation of dominating the universe. Those of the elite should examine their consciences and ask themselves whether they have not betrayed their missions, as did Benda's scholars.* For the men of the elite who do not teach, and who do not seek to improve the lot of the people, are more guilty than the rich who selfishly grab more than their share of material goods.

True, men who are aware of this mission are a tiny minority, but it takes only a little yeast for the dough to rise. This noble and vast design can obviously be pursued only in the midst of popular enthusiasm, and crowds are carried away only when they are offered generous objectives. Neither the great spiritual reforms nor the most sordid revolutions have succeeded unless there was somewhere in the background, confused though it may have been, some hope of improving the lot of humanity, either here or hereafter. Now, youth feeds on enthusiasm and if there is no great cause in sight to merit its cheers, it will either sulk unhappily or rally to the Utopian standard of some charlatan. Youth must therefore be imbued with the generous idea of improving man, his state, and his way of life, which may be independent of any one regime and yet valid for all.

The scholars of the world should set aside their materialistic works and elaborate a program of research for the intrinsic improvement of mankind. The hour has come when men of good will everywhere should join hands in sacred union against the menace of decadence, even the collapse of humanity. But these conclusions can be only provisional until our knowledge is completed and confirmed. Statistical surveys on the mental state of the peoples of the world should give us a sounding on

* *The Treason of the Intellectuals,* by Julien Benda, an attack on scholars with political ambitions.

the influence of the different factors. These conjectures must be verified by strictly controlled experiments on animals and when extrapolation to man is no longer possible, by organizing research on human groups, though realizing the difficulty of experimentation with men because of differences in heredity and environment.

If those of the elite bow out, they will have shirked their sacred mission as trail blazers for humanity, like mounted scouts who, assigned to guide and cover the advance of troops, allow their men to be surprised by the enemy.

And if the necessary recovery does not come in time, they will bear an immense responsibility for the tragic bankruptcy of our civilization.

A Brief Bibliography

General

This book is in some measure a corollary to *Man, the Unknown* (New York: Harper, 1935), by Alexis Carrel (*L'Homme, Cet Inconnu.* Paris: Plon, 1935.) It goes without saying that the reading of this work, as well as of his posthumous book *Reflections on Life* (New York: Hawthorn Books, 1953), (*Réflexions sur la Conduite de la Vie.* Paris: Plon, 1950) is practically obligatory for anyone interested in essential human problems and in the future of our civilization. Whatever we may think of the work of Carrel, the great success of his book shows the primordial importance of the questions so happily approached by the eminent savant.

In the same category we cannot recommend too highly Ellsworth Huntington's basic work *Mainsprings of Civilization* (New York: John Wiley and Sons, 1945). The erudition of the author, professor of human geography at Yale, allows him to introduce original ideas into explaining the appearance and development of civilization, while leaning, of course, on current concepts of heredity and on what we know of the action of physical environment. The chapter on "The influence of nutrition on national character" is of the highest interest, as well as all his studies of the rise and disappearance of civilizations.

The same author's *Principles of Human Geography* (New York:

John Wiley and Sons, 1947) is a study, as scientific as possible, of the interdependence of man and his environment.

Max Sorre's *Les Fondements de la Géographie Humaine* (Paris: A. Colin, 1947) has a similar aim, particularly in its study of the influence of climate on man, and of the ambient milieu on nutrition.

A recent book, *L'Eugénique* by Jean Sutter (Paris: Presses Universitaires de France, 1950) studies the genesis of eugenics and the current techniques for analyzing the quality of populations. One chapter studies the variations of the I.Q. according to family, order of birth, and social environment.

This book is complemented by *Le Niveau Intellectuel des Enfants d'Âge Scolaire* by Prof. and Mme. Henri Pieron and Alfred Sauvy (Paris: Presses Universitaires de France, 1950).

The novel by Aldous Huxley, *Brave New World* (New York: Doubleday, 1932) is an excellent satire on the world of the future, where procreation and the development of man would be entirely rationalized so that citizens would fit perfectly their social functions. It has a certain scientific interest.

And finally we must call attention to *Human Destiny* (New York: Longmans, Green, 1947) by Pierre Lecomte du Noüy (*L'Homme et sa Destinée.* Paris: La Colombe, 1948), which reviews what we know of evolution and tries to infer from it what we may expect from future humanity.

Heredity and Genetics

All the scientific works of Jean Rostand, an eminent author who is both scholarly and literate, should be cited.

His *L'Aventure Humaine* (Paris: Fasquelle, 1947) studies man from germ-plasm to old age. His *L'Homme* (Paris: Gallimard, 1940), while of lesser scope, is an excellent introduction to the study of human problems. And his little book *La Nouvelle Biologie* (Paris: Fasquelle) expounds with talent and precision current scientific thinking on heredity and evolution.

Books on this subject are numerous. Let us cite *Conceptions Modernes de l'Hérédité* by Maurice Caullery (Paris: Flammarion, 1935), which is concerned largely with physiological heredity, and Cuenod's *La Genèse des Espèces Animales* (Paris: Félix Alcan,

1932), which is an over-all study without concealing the difficulty of explaining evolution by mutationism and the absence of all finalism. He studies transformism, the factors of evolution, the genesis of the species, the population of the earth and zoological geography.

Under the heading of psychological heredity, we should point out that the classic works of Le Dantec and Ribot have been largely displaced by the excellent and more rigid *L'Hérédité Psychologique* by Georges Poyer (Paris: Presses Universitaires de France, 1948) and *La Psychologie Différentielle* by Henri Pieron (Paris: Presses Universitaires de France, 1949).

Heredity and Politics by J. B. S. Haldane (New York: Norton, 1938) treats the ensemble of problems of psychological heredity and attacks the racist theory.

The problem of twins is excellently treated by Caullery in his *Biologie des Jumeaux* (Paris: Presses Universitaires de France, 1945) and by Maurice Lamy in *Les Jumeaux* (Paris: Corréa, 1949).

The new problems of teratology are profoundly treated in *La Science des Monstres* by E. Wolf (Paris: Gallimard, 1948), who explains the techniques of experimental teratology as well as the laws of teratogenesis.

And finally let us cite the book by two scholars which shocked scientific circles some years ago, *L'Évolution Régressive* by Georges Salet and Louis Lafont (Paris: Editions Franciscaines, 1943), which kicks back at the classic theories of evolution and points out their weaknesses.

Nutrition

The literature on nutrition is as new as the science itself. The basic laws are clearly and concisely expounded in *L'Alimentation Humaine* by R. Lalanne (Paris: Presses Universitaires de France, 1941), *Les Vitamines* by S. Gallot (Paris: Presses Universitaires de France, 1948), and *Les Tables du Composition des Aliments* by Mme. Randoin (Paris: Lanore, 1947).

Une Expérience Alimentaire en Belgique by Dr. I. G. Bigwood (Brussels: 1940) describes the influence of distributing milk rations and Oslo breakfasts on the nutritional state of Brussels children, aged five to sixteen. The same author has written *Directives pour les*

Enquêtes sur la Nutrition des Populations (Geneva: League of Nations, 1939), which is an excellent guide to dietary research.

The French Foundation for the Study of Human Problems published a wartime *Table de Composition des Aliments* (Paris: 1942).

Les Avitamoses by Drs. Justin Besançon and Klotz (Paris: Flammarion, 1948) is a study of vitamin deficiencies and appropriate therapy.

The Food and Agricultural Organization of the United Nations has published a number of documents on nutrition, the most important of which are *Caloric Needs* (June, 1950), *Alimentary Balance Sheets* (April, 1949), and *Agricultural Alimentary Statistics* (May, 1950).

Some of the works of Dr. Paul Carton have aroused storms of controversy, notably *Les Trois Aliments Meurtriers* (Brévannes, Seine-et-Oise, France: published by the author, 1945).

The book in this category we consider most important is *Nutrition and Physical Degeneration* by W. Price (Los Angeles: American Academy of Applied Nutrition, 1950). This work studies the causes of degeneration through faulty nutrition.

Since this manuscript was finished, Alain de Malleray has published *Pitié pour vos Enfants* (Paris: Amiot-Dumont, 1953), dealing with experiments in the feeding of children and adolescents.

Josué de Castro, former president of the FAO of the United Nations, published a book of major importance in 1952 called *The Geography of Hunger* (Boston: Little, Brown). After reviewing the history of hunger on five continents, the author declares that the specter of hunger resulting from overpopulation is the pure invention of the neo-Malthusians, since sexual fertility is the result of poverty while abundance causes a falling birth rate.

Climate and Physical Environment

Literature in this category is dominated largely by the works of Ellsworth Huntington and Clarence A. Mills.

In *Civilization and Climate* (New Haven: Yale University Press, 1935), Huntington studies the influence of the seasons on human behavior, particularly on health and work.

Dr. Mills, a professor of experimental medicine, makes a more

direct study of the weather and behavior in *Living with the Weather* (Cincinnati: Caxton Press, 1934).

L'Homme et le Climat by André Missenard (Paris: Plon, 1937) and *A la Recherche du Temps et du Rhythme* by Missenard (Paris: Plon, 1940) come to some conclusions which are repeated in this book. Another study of the exchange of heat between homoiotherms and their surroundings is *La Chaleur Animale* by Missenard (Paris: Presses Universitaires de France, 1946).

Temperature and Human Life by Winslow and Herrington (Princeton University Press, 1949) is still another study of thermic relationship between the human body and its surroundings, particularly the techniques of artificial modification of natural climate.

Climate and the Energy of Nations by S. F. Markham (Oxford University Press, 1947) is a more precise study of the influence of climate on human activity and consequently the development of civilization, and concludes that progress is closely linked with the practice of artificial climates.

An important German work by Dr. Willy Hellpach is *Geopsyche* (Leipsig: Engelmann, 1935), and is especially devoted to the psychic influence of climate, weather, and physical environment. The book has an excellent bibliography, and reviews the studies of the subject in various languages.

Education

The author made use of the ample documentation on education in France and abroad in the article *Education et Instruction* by C. Bouglé (Paris: L'Encyclopédie Larousse, Vol. XV, 1939).

La Traité de Pédagogie Générale by R. Hubert (Paris: Presses Universitaires de France, 1946) is an excellent over-all study of the problem under various aspects: theory, practice, and pedagogic methods.

Modern education is the subject of M. A. Bloch's *Philosophie de l'Éducation Nouvelle* (Presses Universitaires, 1948). And it is obviously impossible to speak of modern education without referring to Jean-Jacques Rousseau's *Émile, or Education* (London: Dent, 1933), which is basic.

Another study of modern principles is *Propos sur l'Éducation* by

Alain (Emile Chartier) (Paris: Presses Universitaires de France, 1948).

Educators will read with profit *La Psycho-physiologie Humaine* by Dr. J. Delay (Paris: Presses Universitaires de France, 1945).

Men who have the responsibility for others' souls will be interested in a war memoir called *Souvenir du Temps des Morts* by André Bridoux (Paris: Albin Michel, 1930), which deals with his experience with men in the war of 1914-18.

Modern Labor

The Human Motor by Jules Amar (London: Routledge, 1920) studies man as a machine to which the general laws of mechanics apply. Besides Amar's own research, the book includes the work of such specialists and physiologists as Auguste Chauveau on muscular contraction, W. O. Atwater and F. G. Benedict on the caloric power of foods, and Mosso on muscular fatigue.

Among French commentators on the F. W. Taylor books on scientific management let us cite J. M. Lahy's *Le Système Taylor et la Physiologie du Travail Professionnel* (Paris: Masson, 1916).

Standards, by H. Dubreuil, (Paris: Grasset, 1929) is a study of American labor, *Problèmes Humains du Machinisme Industriel* (Paris: 1946) concentrates on the human factor.

Glossary

A FRIGORE—Produced by cold, especially said of diseases.

AMINO ACID—An organic compound, a factor in proteins, formed by replacing the hydrogen atom in an acid by the NH_2 radical.

CATALYTIC AGENT—A substance that hastens or activates a chemical reaction by its presence but without entering into the reaction.

CORRELATION COEFFICIENT—Sometimes called Pearson's Coefficient. The measure of similarity between two statistical series, relative either to two characteristics of the same individual or the same characteristic in different individuals. When there is perfect identity, the correlation coefficient is 1; when there is none, the coefficient is 0. For instance, in man there is a correlation of 0.96 between the length of the right and left femurs, which means that the two bones are almost equal in length.

DALTONISM—Color blindness, particularly inability to distinguish between red and green.

DIZYGOTIC—The issue of two different eggs, said of fraternal or pseudo-twins.

EMBRYOGENESIS—Study of the formation and development of the embryo (which, in the human species, is called fetus when it can be seen with the naked eye.

ENERGETIC EQUIVALENCE—Equal production of energy.

EUGENICS—Study of ideal conditions for good procreation.

EXOHOMOIOTHERMIA—Maintenance of constant body temperature by

a constant ambient milieu. Some poikilotherms, so-called cold-blooded animals, have constant body temperature because they live in water which is itself constant in temperature.

GENETICS—The science which studies the conditions of reproduction among living creatures.

GERM CELL—Guardian of heredity, as distinct from all other body cells, which make up the soma.

GLUCOSIC EQUIVALENCE—Equal production of glucose or glycose; to be assimilated, sugars and starches must be transformed by the body into glucose.

GYNOGENESIS—Phenomenon producing the development of the ovum by a spermatozoon *without the male chromosomes combining with those of the ovum.* It is parthogenesis induced by a spermatozoon alien to the species or partially annihilated.

HEMOPHILIA—Tendency to unchecked bleeding because of lack of coagulants in the blood. Transmitted through the female line, it attacks males almost exclusively.

HOMOIOTHERM—Warm-blooded animal whose internal temperature is constant, due to regulating systems.

HYPERTHERMIA—A rise in the body temperature of a warm-blooded creature.

HYPOTHERMIA—A drop in the body temperature of a warm-blooded creature.

IDEOMOTOR CYCLE (*reversability*)—Engendering an idea or feeling by taking the physical attitude which generally is provoked by that idea or feeling. For instance, sadness produces tears, therefore tears may provoke sadness.

INTELLIGENCE QUOTIENT (I.Q.)—Relative measure of intelligence according to age. The intellectual age, determined according to fixed tests and averages, is divided by the chronological age and multiplied by 100—which represents the average and eliminates decimal points. A figure of 70 or lower indicates a retarded child. A figure above 130 indicates a gifted child.

LIPOSOLUBLE—Soluble in fats or oils.

METABOLISM—The sum of chemical transformations which take place in the body either by assimilation or dissimilation.

Basal metabolism: The minimum expenditure of energy necessary to the elemental chemical operations of the tissues by activity of the heart, the muscles, the respiratory system, the

smooth fibers of the digestive tract, muscular tonus, etc. It is measured with the patient in a state of complete repose, having taken no food for a dozen hours, and at an ambient temperature of 60° Fahrenheit.

Caloric metabolism: The transformation of physiological energy into heat, generally expressed in kilo-calories per hour.

Peak metabolism: The maximum caloric yield of the body under certain conditions of duration.

MIASMA—Putrid vapors arising from decomposing animal and vegetable matter, and air-borne.

MONOZYGOTIC—Issuing from the same egg; of identical twins.

MORPHOLOGY—Science dealing with the form and structure of animal bodies.

ONTOGENESIS—Repetition in human embryonic development of the embryonic characteristics of the evolutionary ancestors of man according to transformism. During gestation the human embryo retraces the evolutionary steps from protozoa to man, a course covering many millenniums.

ORTHOGENESIS—Oriented development according to a pre-established plan.

PARTHENOGENESIS—Development of the ovum without fecundation. Parthenogenesis may be produced by either chemical or mechanical means. The mechanical method usually consists in introducing an organic element into the ovum.

PHYSIOGNOMY—The art of judging the character and psychology of an individual by studying his facial traits.

PROTEIN—Albuminous element of the body, similar in composition to white of egg and containing principally oxygen, nitrogen, carbohydrates, sulphur.

PSYCHOMORPHOLOGY—Study of the relationship between a person's psychology and his physical form.

REDUCTION (*chromosomal reduction*)—The elimination of one chromosome of each pair when the germ cell is formed. In woman the pre-ovular cell divides into two, each of which contains only twenty-four chromosomes. One of these cells miscarries and the other redivides to form the ovum. One-half of the mother's heredity is thus discarded according to laws we do not yet understand. Science has not yet discovered what governs the choice or rejection of chromosomes.

SCHIZOPHRENIA—Split personality; a mental disorder in which the patient loses touch with his environment.

SOMA—The sum of all body cells with the exception of the germ cell.

SOMATIC—Pertaining to the body.

SUPERFECUNDATION—Fertilization by two different males of two ova issuing in quick succession.

SUPERFETATION—Fertilization of a second ovum during pregnancy.

TEMPERATURE—*Thermic neutrality:* Temperature at which warm-blooded creatures are aware of no sensation of heat or cold and which induces a feeling of well-being.

Resultant Temperature: The sensation of heat or cold experienced by the human body in a given environment, depending upon the temperature of the walls of the premises, the dry-bulb temperature of the air, the rate of circulation of the air and the relative humidity.

Wet-bulb and dry-bulb temperatures: Wet-bulb temperature is measured by a thermometer the bulb of which is kept constantly damp by a strip of cloth with one end dipped in a container of water. A wet-bulb thermometer measures the rate of evaporation and thus, by comparison with a dry-bulb reading from an ordinary thermometer, will indicate the *relative humidity.*

TERATOLOGY—A science which studies monsters and particularly the conditions which produce them (*teratogenesis*).

TROPISM—Movement toward or away from an external stimulus by living organisms, even those without central nervous systems, such as plant life. The simplest example is that of heliotropism, which causes some plants to turn toward the sun; or the attraction of certain larvae to light.

VASIDILATION—Expansion of the peripheral blood vessels inducing increased blood circulation near the skin.

VASOCONSTRICTION—Diminution of the diameter of the peripheral blood vessels, reducing the circulation of the blood in the vicinity of the skin.

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